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MINING METHODS AND PRACTICES AT INTERNATIONAL MINERALS & CHEMICAL CORP. POTASH MINE EDDY COUNTY, N. MEX.

BY

GEORGE T. HARLEY AND WALTER R. STORMS

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MINING METHODS AND PRACTICES AT INTERNATIONAL MINERALS & CHEMICAL CORP., POTASH MINE, EDDY COUNTY, N. MEX.[1]

By George T. Harley[2] and Walter R. Storms[3]

CONTENTS

Page
Introduction and summary.......... 2
Acknowledgments.......... 2
History.......... 3
Geology.......... 4
Methods of prospecting and exploration.......... 5
Methods of sampling and estimation of tonnages and values.......... 6
Development methods.......... 7
  Shafts.......... 7
  Main and cross entries.......... 9
  Drilling and blasting.......... 10
Mining methods.......... 11
  Mining.......... 11
  Undercutting.......... 12
  Loading and haulage.......... 12
Transportation.......... 13
Ventilation.......... 14
Drainage.......... 15
Safety measures.......... 15
Wage scale.......... 17
Organization.......... 19
Appendix (Mine operating data.).......... 20
Bibliography.......... 21

ILLUSTRATIONS

Fig. — Follows Page
1. Index map.......... 2
2. Topographic map.......... 2
3. Aerial view of surface plant, looking easterly, showing No. 1 shaft in right-hand section and No. 2 shaft in left-hand section, distant view.......... 2

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[1] Manuscript completed Aug. 23, 1948. The Bureau of Mines will welcome reprinting of this paper, providing the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7511."

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ILLUSTRATIONS (cont'd.)

Fig.		Follows Page
4.	General map of 900-foot level with No. 1 shaft at left and No. 2 shaft near center of map	6
5.	Ideal section through mine; No. 1 shaft at left and No. 2 shaft at right	6
6.	Section through No. 1 shaft	6
7.	Undercutting machine	8
8.	Drilling room face showing post-mounted electric auger drills	8
9.	Loading machine loading shuttle car in room	10
10.	Standard 3- and 5-hole entry rounds	10
11.	Map of area on 900-foot level	12
12.	Moving undercutting machine	12
13.	Trolley-type shuttle car	12
14.	Storage-battery shuttle car unloading into conveyor, which is loading mine car	12
15.	Trolley-type locomotive	12
16.	Rotary dumper unloading cars at No. 1 shaft on 900-foot level	14
17.	Spotting drill holes on room face	20

INTRODUCTION AND SUMMARY

This paper, which describes mining methods at International Minerals & Chemical Corp.'s potash mine in Eddy County, N. Mex., is one of a series being prepared by the Mining Branch of the Bureau of Mines on mining methods and practices in various mining districts of the United States.

The mine shafts and surface plant of International Minerals & Chemical Corp. are situated in sec. 12, T. 22 S., R. 29 E., N. M. P. M., about 26-1/2 miles by paved highway east of the city of Carlsbad (figs. 1, 2, and 3). A spur line of the Atchison, Topeka & Santa Fe Railroad connects the mine with the Clovis-Pecos branch of the same road near Loving, a few miles south of Carlsbad. This spur also serves the refinery of United States Potash Co.

This report gives the history and describes the geology of the district. Methods of prospecting, exploration, sampling, and estimation of tonnage and values are explained; development and mining methods are discussed in considerable detail; transportation, ventilation and drainage are outlined; safety measures are noted; and the wage scale and organization are mentioned.

ACKNOWLEDGMENTS

The Bureau of Mines recognizes the importance of collecting information on mining methods and practices of individual mines and presenting it in circular form for distribution throughout the mining industry. The Mining Division, Lowell B. Moon, chief, conducts field examinations, collects the required essential information, and prepares the circular.

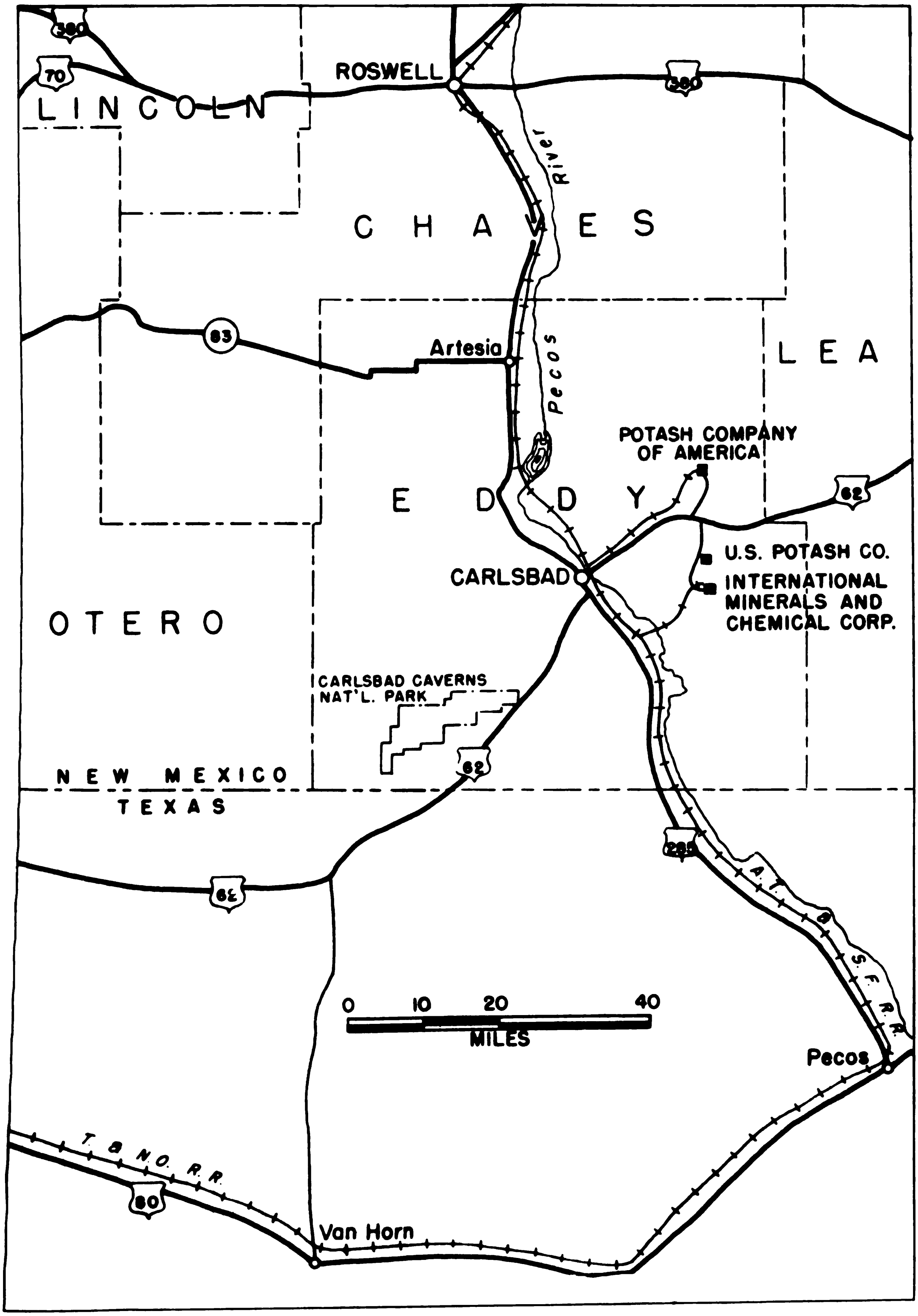

Figure 1. - Index map.

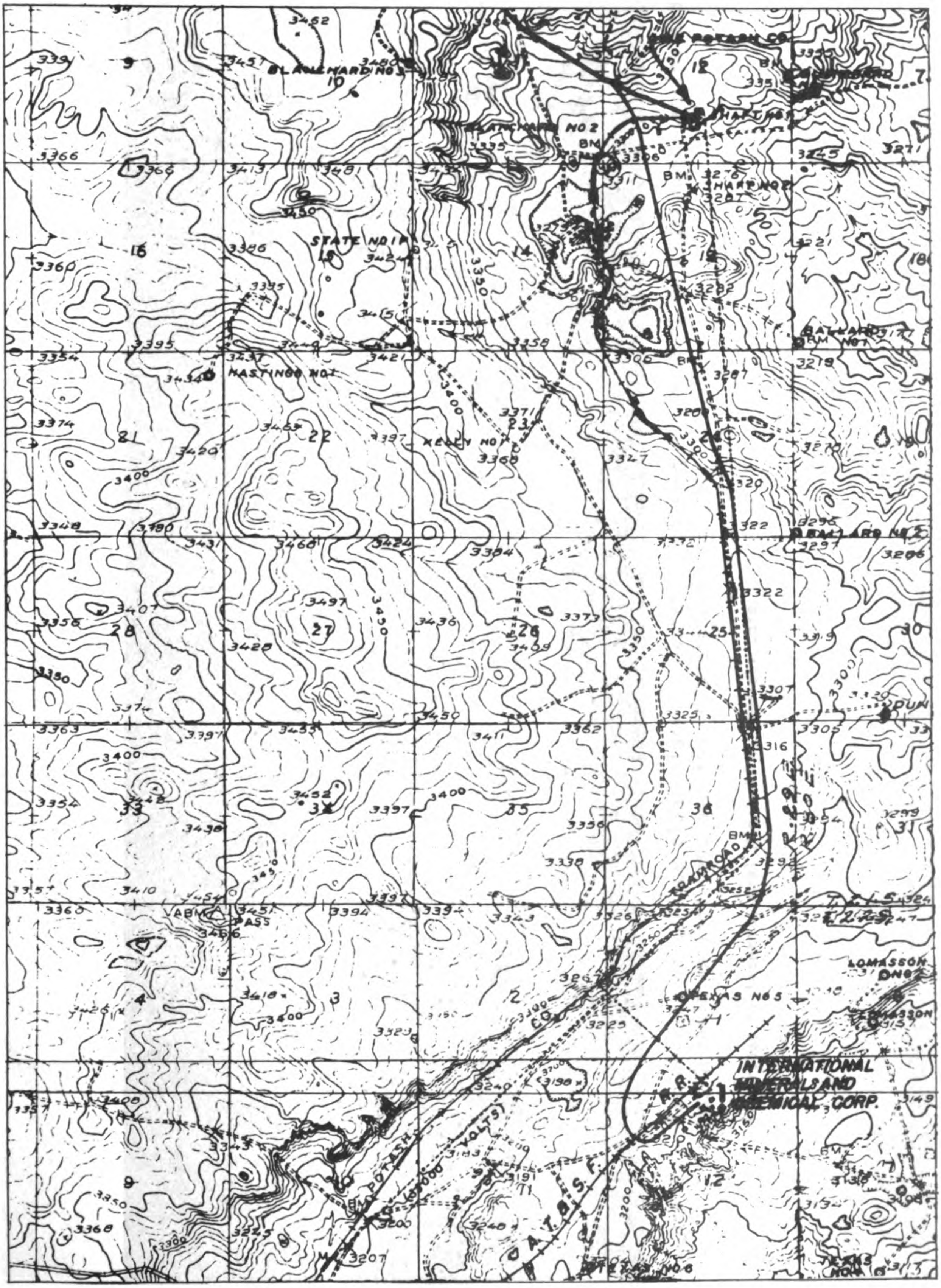

Figure 2. - Topographic map.

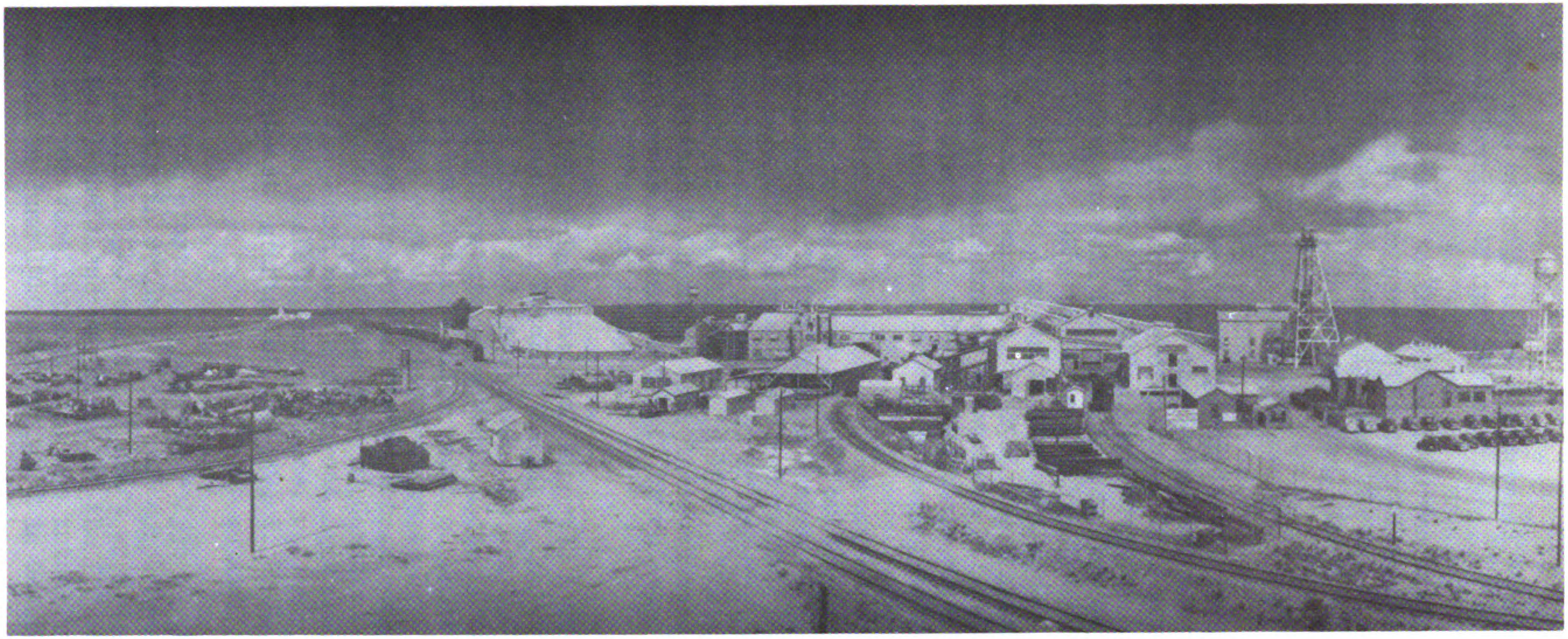

Figure 3. - Aerial view of surface plant, looking easterly, showing No. 1 shaft in right-hand section and No. 2 shaft in left-hand section, distant view.

(Courtesy of International Minerals & Chemical Corp.)

This circular was prepared under the general supervision of J. H. Hedges, chief of the Tucson Branch, Mining Division.

Acknowledgment is made to the executives and staff of International Minerals & Chemical Corp. for permission to publish this paper and for their valuable assistance. Special acknowledgment is due W. P. Morris, mine superintendent, G. C. Weaver, chief engineer, and H. L. Gardner, mine engineer.

HISTORY

In 1911 Congress made the first appropriation available for potash research to the Bureau of Soils and the Geological Survey. Although funds were limited, many possible sources of potash, including brines and saline deposits, were investigated. In 1912 J. A. Udden, of the University of Texas, discovered potash salts in well bailings in the Permian basin in Dickens County, Tex. Finally, in 1926 the Bureau of Mines and the Geological Survey obtained an appropriation to core-drill the salt strata of the Permian basin in New Mexico and Texas. Meanwhile, in 1925 the Snowden & McSweeney Co. had found crystals of the potash mineral sylvite in oil-well bailings near Carlsbad, N. Mex. This latter discovery, together with the work by the Government bureaus, led to the establishment of the present potash industry near that city.

The first company to begin work in the Carlsbad district was the American Potash Co. (later changed to United States Potash Co.), which started to sink its first shaft in 1929 and shipped its first potash ore in 1931. The second company to begin operations was Potash Co. of America, which started its main shaft in 1933 and shipped the first ore in 1934. The third company in the district was Union Potash & Chemical Co., later changed to the Potash Division of International Minerals & Chemical Corp., which started shaft sinking in 1936 and shipped its first ore in 1940.

The Potash Division of International Minerals & Chemical Corp. originally was organized in 1936 as Union Potash & Chemical Co. when the leases and assets of Texas Potash Corp. and Independent Potash & Chemical Co. were consolidated. The property consists of several thousand acres of leased State and Government land situated a few miles south of United States Potash Co.'s mine, about 26-1/2 miles east of Carlsbad by paved U. S. Highway 62 and a paved road southward past the United States Potash mine to the International. The mine, which is about 17 miles due east of Carlsbad in an air line, also may be reached from the south over a dirt road from near United States Potash Co.'s refinery. The No. 1 shaft, main office, refinery, shops, etc., are situated in the northeast quarter of sec. 12, T. 22 S., R. 29 E. (figs. 2 and 3.).

The No. 1 shaft was started in September 1936 but was stopped in November 1937, then started again in October 1938, and completed to a depth of 992 feet in January 1940. In April 1940 the No. 2 shaft was started some 4,100 feet northeast of the No. 1 shaft and was finished the following year. This No. 2 shaft was to be used for ventilation, etc. An intensive underground-development campaign was started in June 1940 and finished in October of the same year.

Work on the refinery was started in June 1940 and completed in September. In January 1941 the mine was producing about 2,000 tons of ore a day; at the present time (January 1948) the output has been increased to over 5,400 tons daily.

GEOLOGY

The general geology in the Carlsbad potash district is similar at all three of the producing mines. The surface is covered with sand, caliche, and gypsite to a depth of several feet; the Rustler formation, of Permian age, occurs below the surface material for a depth of several hundred feet; then the Salado (salt) formation (also Permian), which contains the potash deposits, occurs beneath the Rustler.

The Rustler formation is of late Permian age and lies unconformably upon the Salado formation. It is approximately 400 feet thick and consists principally of gypsum and red beds, with several dolomite, sand, and gravel beds. Some of these dolomite beds are porous and contain large amounts of water; because this water usually contains gypsum and other salts, it is not suitable for human consumption.

At the No. 2 shaft about 35 feet of sand, caliche, and gypsite occur underlain by the Rustler formation from 35 to 407 feet. At 407 feet the Salado formation is encountered. From 215 to about 250 feet the water-bearing Rustler dolomite, the largest of the water-bearing dolomite beds, occurs. Below this dolomite lies the Rustler formation, which consists chiefly of clay and shale, with some gypsum.

The Salado or salt formation, which lies beneath the Rustler, consists chiefly of halite beds separated by beds or bands of anhydrite and polyhalite. Some of the halite beds are over 100 feet thick, but the anhydrite and polyhalite range from only a few inches to a few feet. The maximum thickness of the Salado in the vicinity of the mine probably is about 1,600 feet. There are about 45 persistent sulfate beds and as many halite beds. The potash deposits lie near the middle of the formation as originally laid down and 650 to 900 feet beneath the surface. Through this 250-foot thickness there are numerous thin beds rich in potash-bearing minerals, chiefly sylvite, with langbeinite and some carnallite. At the International mine, two such beds are being mined. The No. 2 bed (or No. 26 bed, as named by the Geological Survey) occurs about 755 feet beneath the surface and is being mined for its langbeinite content. Some sylvite occurs in this bed, although it is made up chiefly of langbeinite. The No. 2 is persistent in occurrence on the property, but its potash values are very erratic. The No. 4 bed (or 28 bed, according to the Survey) also is being mined. This bed occurs about 880 feet below the surface and consists of sylvite with halite. On the property the No. 2 bed averages 5 feet in thickness, whereas the No. 4 (or 28) bed averages 9 feet where mined. Both beds grade rather abruptly into barren halite both above and below, but the lateral transition generally is more gradual. However, barren masses of halite, called "salt horses", occur irregularly throughout both beds.

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METHODS OF PROSPECTING AND EXPLORATION

All prospecting and exploration at the property of International Minerals & Chemical Corp. were limited to drilling holes from the surface. Most of the holes were churn-drilled from the surface through the Rustler to the Salado formation, then diamond-drilled through the Salado to a point well below the 28 bed. Nine holes were drilled before Union Potash & Chemical Co. was organized. Since then many additional holes have been drilled, the more recent ones through the Rustler by rotary drill, then into the Salado by the same rig using a diamond bit and core barrel. The first holes were spotted somewhat at random, but later holes were planned to explore the property thoroughly in advance of underground development and mining.

In the method where churn drilling was used through the Rustler formation, the hole usually was started 10 inches in diameter, then reduced to 8 inches, and finally to 6 inches, so that a 5-3/16-inch casing could always be placed in the top of the salt. The hole was churn-drilled into the salt for several feet so the last casing would have solid foundation. This casing was securely sealed at the bottom, so that water from the Rustler formation could not get into the hole and also to prevent the solution used in core drilling the Salado formation from leaking out at the top of the salt into the more porous Rustler formation. After the 5-3/16-inch casing was set in the salt, the hole was continued with a diamond drill, which cut a 2-1/2-inch core. During diamond drilling a special double-tube core barrel was used. A brine solution was used instead of water, so that the salt core would not be dissolved. Usually a saturated sylvite solution was used, although it has been found that a saturated carnallite solution seems to be better, as it prevents leaching or etching of any carnallite in the core. The solution was pumped down through the drill rods, then between the inner and outer tubes of the special core barrel, then out to the bottom of the drill hole through small holes in the face of the diamond bit. In this way the drilling solution came in contact with the core only at the cutting face of the bit, and etching or leaching of the core by the solution was kept at a minimum

When a rotary drill rig was used, the hole through the Rustler was drilled by employing a regular rotary bit, and the drill outfit was mounted on a large truck. After the hole entered the top of the salt, it was cased; then the rotary bit was exchanged for a double-tube core barrel and special diamond bit, and drilling was continued with a brine solution, as explained when the hole had been started from the surface with a churn drill. More detailed descriptions of the special techniques used in drilling the salt formation have been published.[4]

METHODS OF SAMPLING AND ESTIMATION OF TONNAGES AND VALUES

The physical differences between potash ore and halite (salt) are such that visual inspection by the sampler or boss will determine what is ore and what is waste. The top limit of the ore is sharply defined, as it lies directly below a pronounced clay seam. The top holes in a room, breakthrough, or entry round are so drilled that they end in this seam. The lower limit of the sylvite ore varies from 3.0 to 4.5 feet below the lower salt marker. The mine samplers watch this lower limit very carefully, and every two weeks they issue a corrected "standard" sheet, which gives the position of the lower ore limit measured in feet and inches down from the top of the lower salt marker. Abrupt variations with respect to the lower limit are noted immediately.

At times selective mining is resorted to, as when the lower half of the face is in salt. In that case, undercutting and drilling proceed as usual, except that the lower half (the salt) is blasted first. The salt is loaded out; then the top half of the face is blasted and loaded out as ore.

On both the 800- and 900-foot levels channel samples are cut along the rib in all rooms and breakthroughs. These samples are cut so that they always occur on a pillar. In this way the position of the sample is not destroyed, and after plotting its position on the assay map it could be re-cut and checked if the need should ever occur. Over a period of time it is felt that the average analyses of these samples give a fairly true value of the ore in place. Samples are cut only in ore, beginning at the top of the face and proceeding downward until either the lower limit of the ore or the floor is reached.

In sampling the cores from exploratory drilling, they were first measured in the field, then placed in core boxes, and taken to the main mine plant.

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[4] 1. Wroth, Jas. S., Special Features of Core Drilling in the Salt Beds of Western Texas and New Mexico: Bureau of Mines Inf. Circ. 6156, 1929, 13 pp.
2. Hayes, E. P., Supplementary Notes on Core Drilling in the Salt Beds of Western Texas and New Mexico; Tests 13 to 24: Bureau of Mines Inf. Circ. 6679, 1933, 11 pp.
3. Pierce, R. A., and Anderson, L. D., Potash Company of America - Producer of Sylvite at Carlsbad: Eng. and Min. Jour., vol. 142, No. 12, December 1941, pp. 38-39 (description of drilling).
4. Storms, W. R., Diamond Drilling of Potash Reserves in Eddy County, N. Mex.: Bureau of Mines Rept. of Investigations 3861, April 1946, 11 pp.
5. Harley, G. T., and Weaver, G. C., Prospecting for Potash in the Permian Basin Area, Near Carlsbad, New Mexico: Am. Inst. Min. and Met. Eng. Tech. Pub. No. 2056, Chicago Meeting, February 1946, 6 pp.

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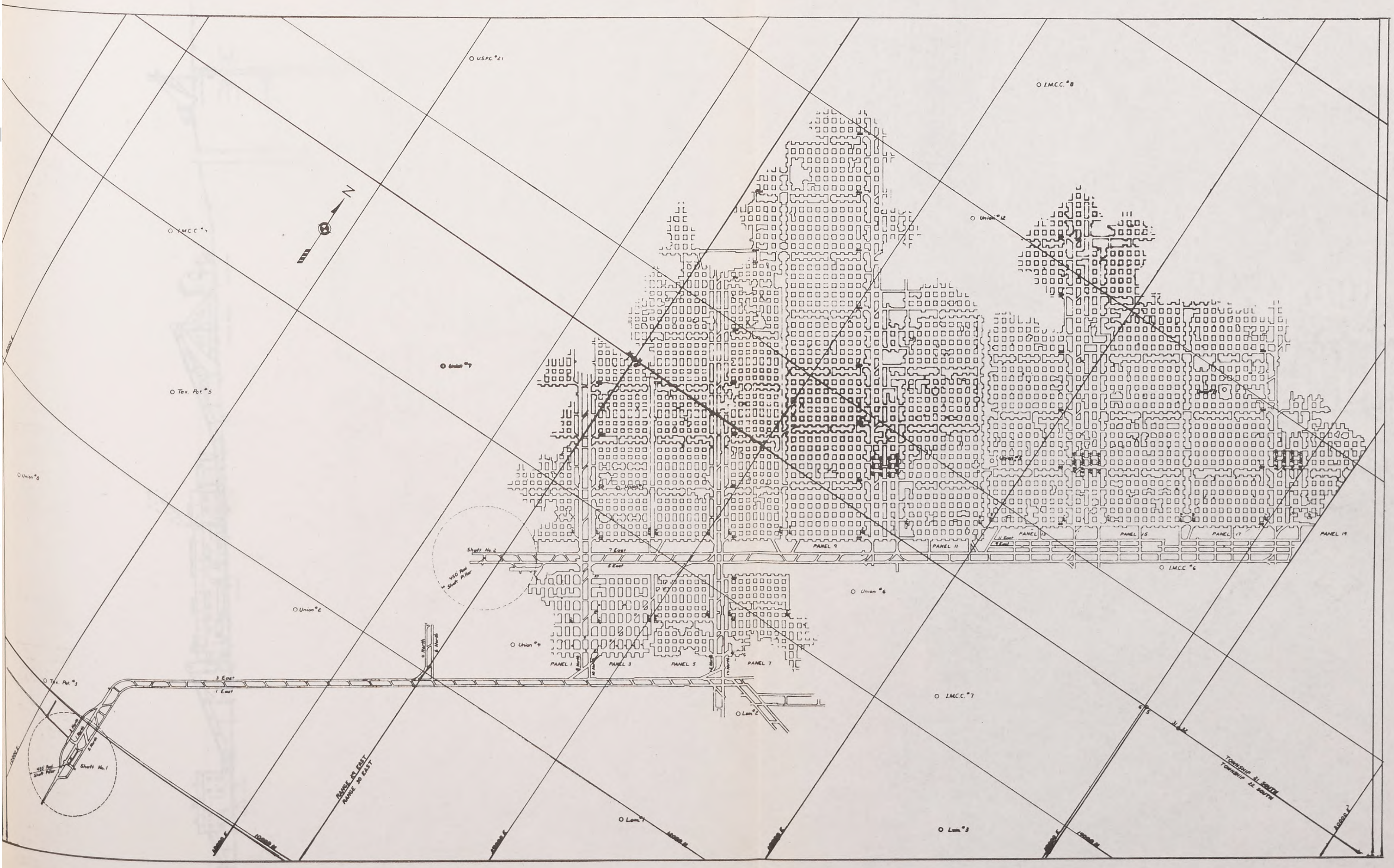

Figure 4. - General map of 900-foot level with No. 1 shaft at left and No. 2 shaft near center of map.

(Courtesy of International Minerals & Chemical Corp.)

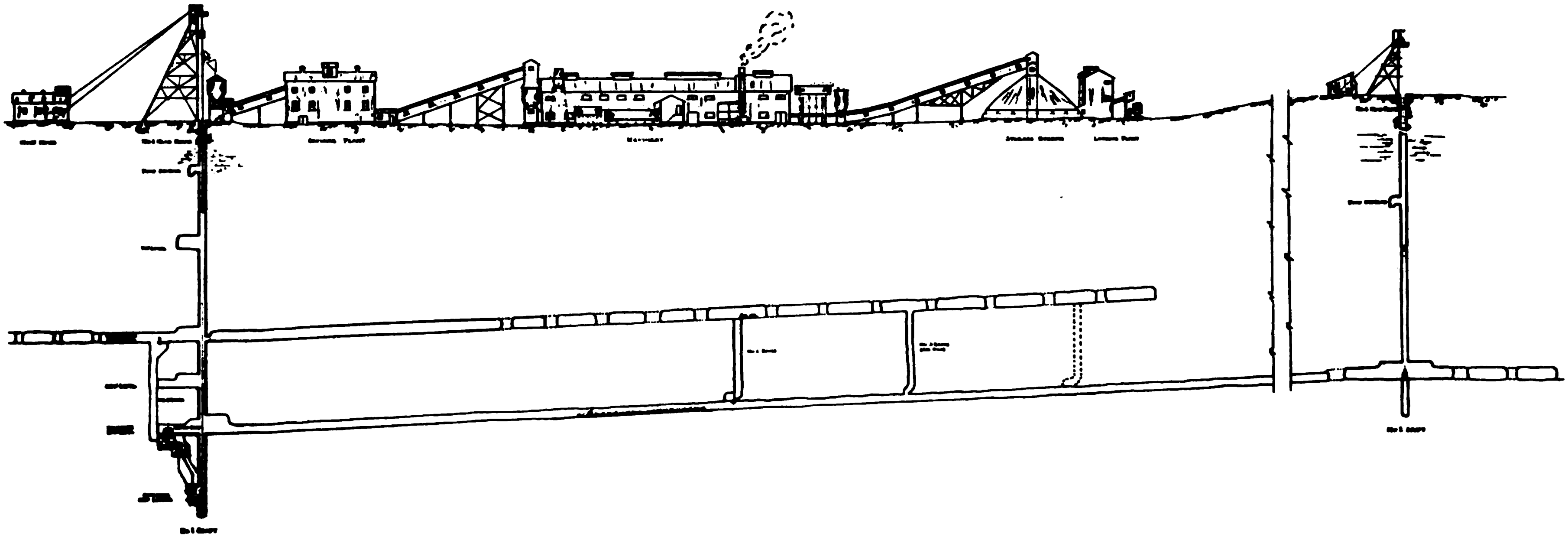

Figure 5. - Ideal section through mine; No. 1 shaft at left and No. 2 shaft at right.

(Courtesy of International Minerals & Chemical Corp.)

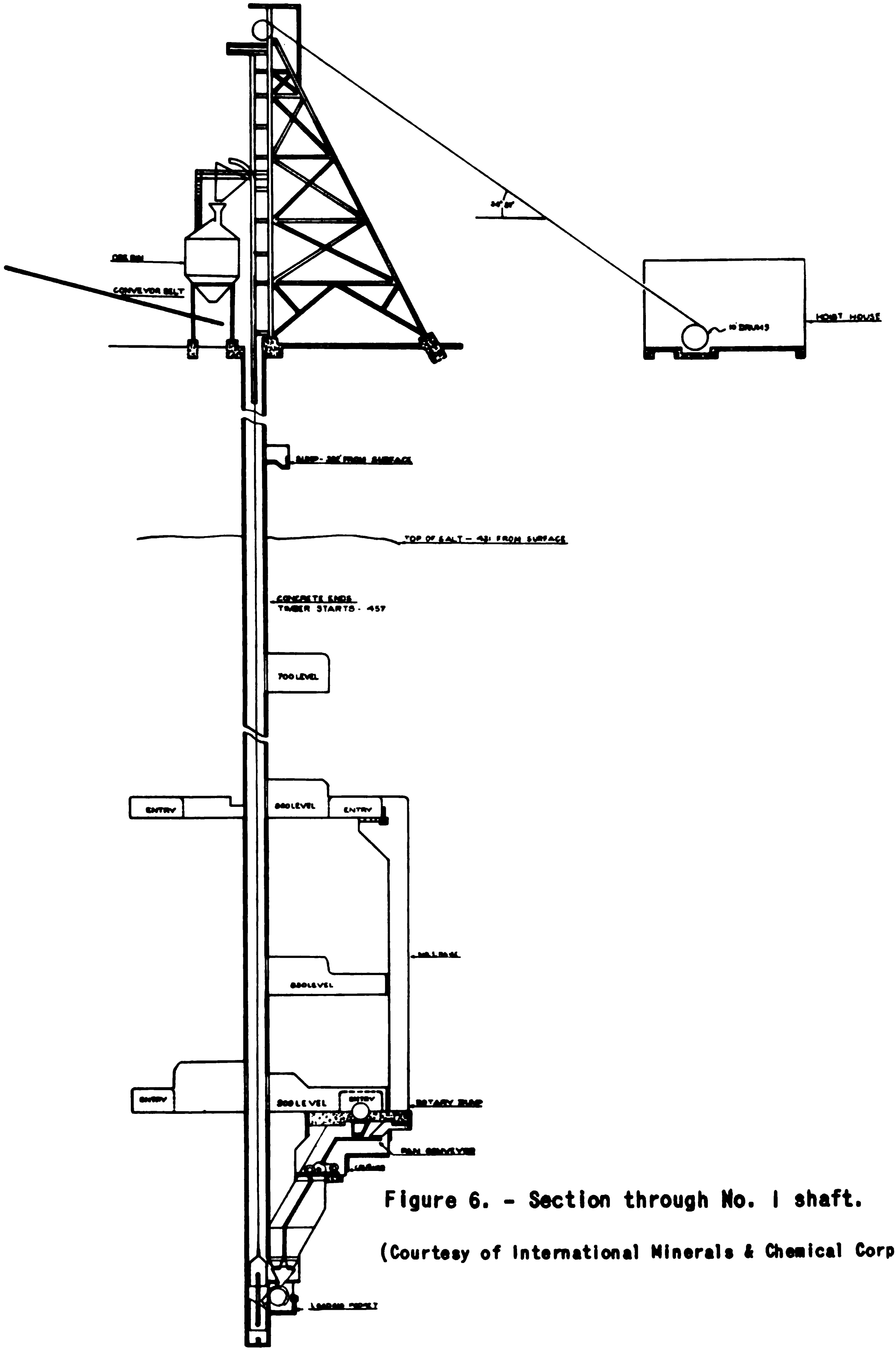

Figure 6. - Section through No. I shaft.

(Courtesy of International Minerals & Chemical Corp.)

Wooden boxes, which hold 25 feet of core in five 5-foot rows, usually are used, but recently fiberboard boxes that hold 10 feet of core in five 2-foot rows have been used. The latter boxes are much easier to handle, as they weigh much less than the wooden boxes. At the mine laboratory the core that contains ore is split in halves, then one of the halves is split into quarters. One quarter is delivered to the Federal Geological Survey for their record when the hole is drilled on leased Government land, whereas the other quarter is analyzed by company chemists. The second half is kept at the mine for a record.

In the mine laboratory a complete colored strip log of the core is made, and a written log noting all measurements and details is prepared.5/

In estimating tonnages and values of ore, the core from each surface drill hole that encounters ore is assumed to be representative of an area around it having a radius of 1,000 feet. Holes are usually drilled about 2,000 feet apart, so that circles with 1,000-foot radiuses drawn around them are tangent or slightly overlapping. When several holes so drilled show the presence of ore of commercial grade and thickness in a bed, such ore is assumed to be continuous and is outlined by straight lines drawn tangent to the outer adjacent circles in the group for an area estimation of the ore. Isopachs then are drawn across the area outlined, the areas of which are found with a planimeter. Core analyses are weighted according to the thickness of the bed at each hole, and the grade of the ore body is estimated by arithmetically averaging the analyses of adjacent drill holes to apply to the areas between them. This method of calculating ore reserves has proved to be quite accurate, as the grade of ore as mined has been within 1 percent of that estimated.6/

DEVELOPMENT METHODS

Shafts

The main or No. 1 shaft (figs. 3, 4, 5, and 6) at the International mine was started in September 1936 and completed to a depth of 992 feet in January 1940. Work was stopped on this shaft in November 1937, then started again in October 1938. No. 2 shaft (figs. 3, 4, and 5) was started in April 1940 and finished the following year to the 900-foot level. Both shafts are connected to the two mine levels - the 800-foot level, which is 787 feet below the collar of No. 1 shaft, and the 900-foot level, which is 902 feet below the collar of the same shaft.

No. 1 shaft was sunk with compressed air-powered drills and a small single-drum hoist driven by a 125 horsepower electric motor. This hoist later was used for sinking No. 2 shaft 4,100 feet northeast of No. 1. No. 1 has three compartments, each 5 feet 6 inches by 5 feet 8 inches inside the shaft timbers. Two compartments are for hoisting, and the third is a manway. It is concreted from the surface to 25 feet below the top of the salt, or for a depth of about 430 feet. The shaft is timbered with 8- by 8-in. fireproofed timbers from the surface to the bottom. As the salt stands very well no concrete was necessary below the 430-foot point.

5/ Harley and Weaver, cited in footnote 4.
6/ Harley and Weaver, cited in footnote 4.

No. 2 shaft also was concreted from the collar to the 430-foot point, or 23 feet into the salt. It is timbered above the salt, similar to No. 1, with two hoisting compartments, each 5-feet 6-inches by 7 feet in the clear, and a 7- by 8-foot manway. Below the concrete, one end plate and two dividers are placed in hitches cut in the salt and then sealed in with concrete. These form two hoisting compartments and a manway. End plates and dividers are 8- by 8-inch steel "H" beams. The hoisting compartments in the salt both are 5-feet 6-inches by 7 feet, whereas the manway is 8 feet long by 7 feet wide.

No. 1 shaft is used for hoisting ore, men, and supplies, and for ventilation. No. 2 shaft is used for men and supplies as well as for ventilation. At No. 1 the shaft was sunk 90 feet below the 900-foot level to provide space for a crusher, bins, and a skip loader. At No. 2 shaft a small sump and pump station were located at the 425-foot point to catch any water that might enter the shaft, however, none was encountered in sinking this shaft. In sinking No. 1 shaft the main water-bearing stratum was encountered between 220 and 240 feet below the collar. A 6-inch pipe ring was installed around the shaft at the 240-foot level, where the water was collected and then transported by a 6-inch vertical pipeline down to a pump station on the 302-foot level. There the water was collected in a sump, then pumped to the surface. Pumping is automatically controlled. It is estimated that about 100 gallons a minute are handled.

In sinking No. 2 shaft, a crew of nine men was used on each of three shifts. This crew consisted of one shift boss, five miners, two toplanders, and one hoistman. The six men in the shaft did all work, including blasting, mucking, timbering, and concreting. In general, the practice in sinking through the Rustler formation above the salt was to keep the bottom of the shaft 25 to 30 feet below the last timber set. After each round was blasted and mucked, another set of timbers was placed. When four sets (covering 20 feet) had been placed below the last concreted section they were lagged flush with the outside of the timbers, and the open space between the last set and the rock walls was closed by nailing planks to the bottom of the set. These planks served as a footing for the concrete. After the reinforcing steel was placed, concrete was lowered in a bucket and poured from the last set upward. The concrete of the previously poured sets was chipped off at a slant all around the walls at its lower end to furnish a fresh bonding surface. Anchor pins made of short pieces of reinforcing steel were placed in holes drilled into the rock walls of the shaft to serve as a bond between the concrete and the rock, or hitches were cut in the rock walls at intervals and allowed to fill with concrete.[7]

No. 1 shaft sinking procedure was similar to that for No. 2 shaft.

Shaft pillars having a 450-foot radius were left around each shaft at the 800- and 900-foot levels for protection.

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[7] Hubbell, A. H., The Union Potash & Chemical Co.'s Enterprise at Carlsbad: Eng. and Min. Jour., vol. 142, No. 4, April 1942, pp. 48-50.

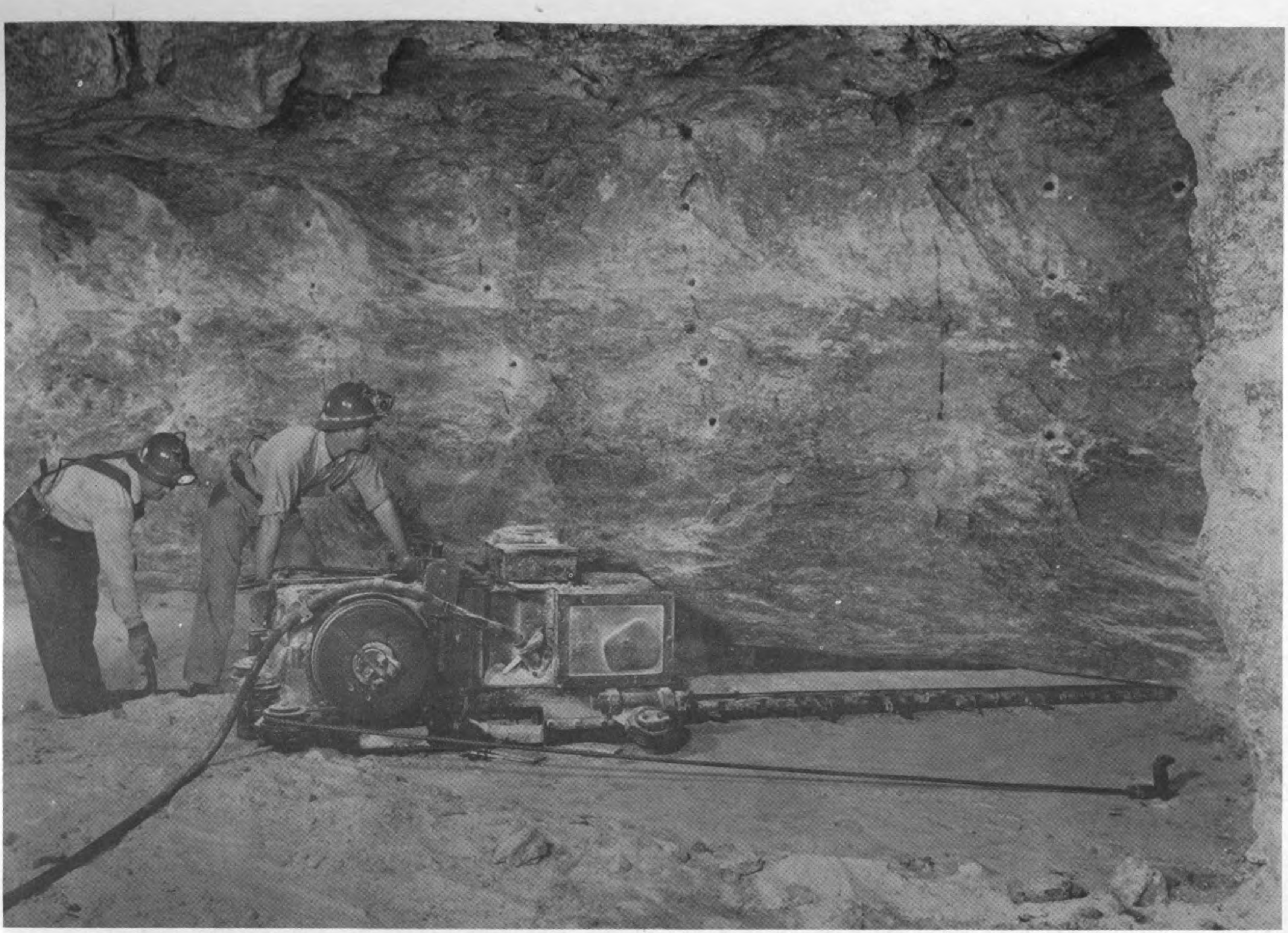

Figure 7. - Undercutting machine. (Courtesy of International Minerals & Chemical Corp.)

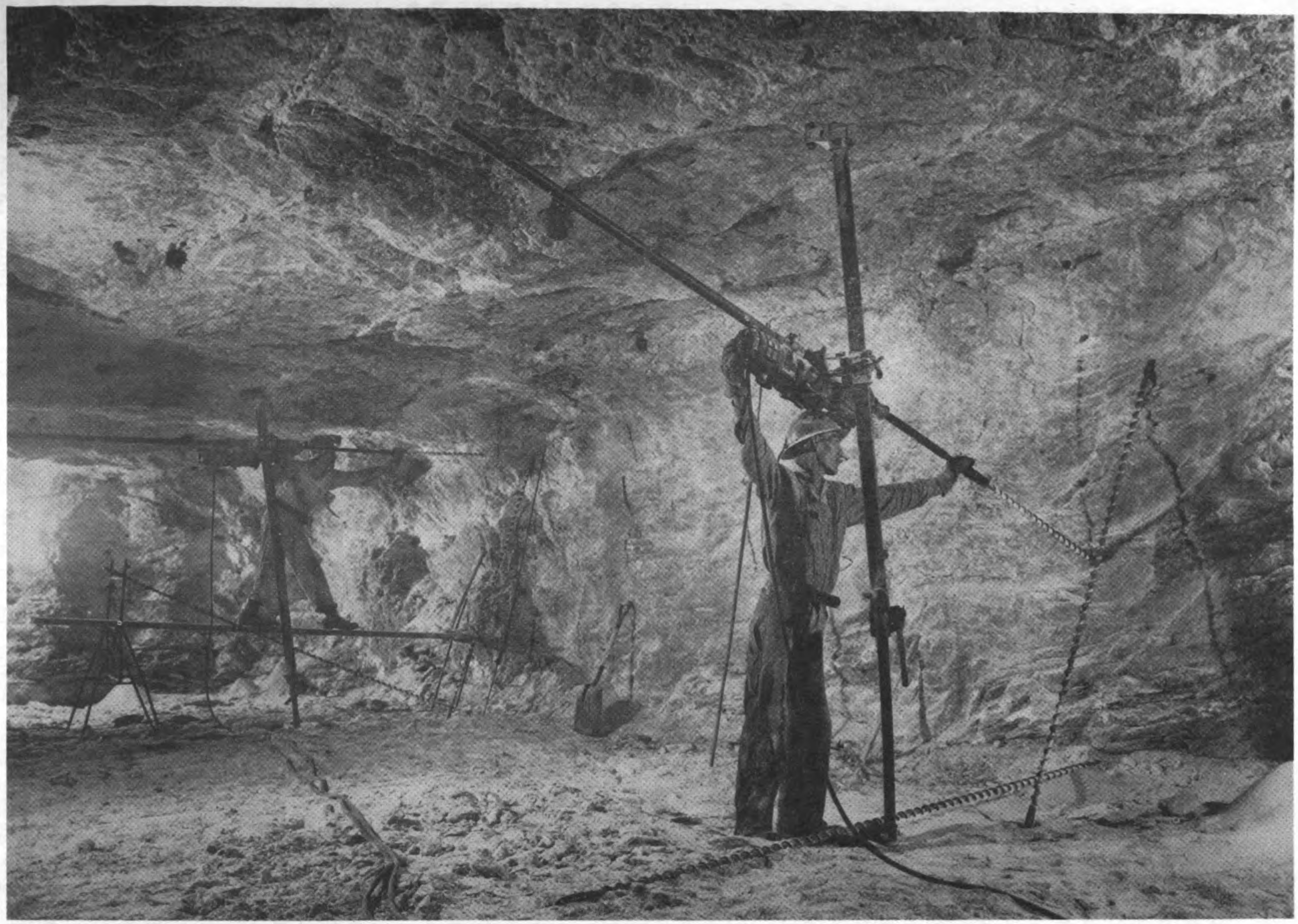

Figure 8. - Drilling room face showing post-mounted electric auger drills.

(Courtesy of International Minerals & Chemical Corp.)

Main and Cross Entries

After shaft stations had been cut on the 800- and 900-foot levels, the driving of double entries began from No. 1 shaft to the ore deposits. This shaft had been completed in January 1940. By May 1, 1940, 600 feet of double entry had been driven on the 900-foot and 150 feet on the 800-foot level. Work then was stopped temporarily pending the arrival and installation of a rotary dump at the No. 1-shaft 900-foot level station, skips in No. 1 shaft, and mechanical loaders, undercutters, electric drills, and haulage equipment for the mine.

As the potash-bearing beds were lying nearly horizontally, it had been decided to use coal-mining methods and machinery to mine the ore, as was being done in the other two potash mines in the district. All underground operations were to be mechanized as much as possible, and electricity was to be used almost solely for power. A cable in the shaft from the power house on the surface to the 800-foot and 900-foot levels furnished alternating current at 2,300 volts. Portable transformers on each level stepped this current down to 220 volts for use in electric drills, undercutters, loaders, etc. Motor-generator sets changed the alternating current to 250-volt direct current for trolley locomotives and battery-charging sets.

Intensive development work was started on the 900-foot level on June 1, 1940, in order that ore might be developed and mining started by the time the refinery was finished. On September 28, 1940, the driving of entries was started again on the 800-foot level. The No. 1 shaft had been sunk very close to the langbeinite deposit on the 800-foot level, but was some distance from the main sylvite ore body on the 900-foot level, so several thousand feet of entry had to be driven on the latter before ore could be reached. On this level double entries were driven due north from No. 1 shaft for 820 feet with frequent breakthroughs between entries for ventilation. From the 820-foot point the entries were driven No. 56° 04' E. to the sylvite deposit. Entries on the 800-foot level were driven directly above the 900-foot level entries, but for only a short distance, as the langbeinite deposit was situated close to the shaft.

From No. 1 shaft to the 900-foot level ore body the entries were carried 15 feet wide and 8 feet high, the double entries being 53 feet apart, center to center. At first, breakthroughs 8 by 15 feet in cross section and 38 feet long were spaced 150 feet apart. Later, the breakthrough interval was lengthened to 180 feet when it was found that ventilation was good in the entries. When the sylvite ore body was entered, entries were widened to 20 feet.

Coal-mining equipment embracing shortwall undercutters (fig. 7) with 9-foot cutter bars were used to undercut the face of an entry. These machines cut a kerf about 5-1/2-inches wide and 8-1/2-feet deep across the bottom of the entry face. This gave two free faces for blasting and helped reduce the powder consumption, as the salt formation is very "rubbery" and difficult to break. Entry faces were drilled by using electric post drills (fig. 8) and auger steel with special detachable bits. During the period of intensive development work, miners drilled on one side of an entry face while the undercutter was working on the other side. At first 40-pound rail was used in the entries, but these were later replaced by 60-pound rails. Forty-pound rails were used near the face and were replaced by heavier ones as the entries advanced. The broken muck from the two headings was loaded by trackless-type loaders (fig. 9) into 5-1/2-ton mine cars, which were spotted at the loaders and then taken, when loaded, to sidings a short distance behind the face by 6-ton storage-battery locomotives. Cars then were picked up from the sidings by 8-ton trolley and cable-reel locomotives and taken to the shaft station.

In driving the entries during this initial development campaign, three shifts were worked. The crew at the face on each shift consisted of a shift boss, an undercutter operator and helper, three drillers, a loader operator and helper, a motorman on the gathering locomotive, and a laborer or nipper. In addition to these nine men at the face, there were six additional men, comprising a repairman, a powderman or shot firer, a mucker, the hoistman, and two topmen. A crew of electricians installed trolley lines, power cables, etc.

On the 900-foot level the crews averaged 42.3 feet per day for the first week after June 1, 42.7 feet the second week, and 55.1 feet the third week. On July 15 the development work was placed on a bonus basis, and the daily footage rapidly increased until 153.3 feet were driven on September 18. On that day a round was undercut, drilled, and blasted in 70 minutes in one heading while the loading crew was mucking out the other entry. In this work 70 tons were broken and moved per round and 15 to 19 8-foot rounds were broken per 24 hours. Time studies were made at the time by G. T. Harley, who then was general superintendent. These studies are summarized in an earlier publication.[8]

When the sylvite body on the 900-foot level was reached, double cross or panel entries were turned off the main entry at 90-degree angles every 1,160 feet and driven up the ore body. On October 26, 1940, this intensive development campaign was stopped, and the actual mining of ore began. The refinery began treating langbeinite ore on October 1 and sylvite ore a little later.

Later development work has been carried on in much the same way although at a much slower pace.

Drilling and Blasting

Drilling and blasting in the International mine is much the same in development workings and in the rooms where the actual mining takes place. Post-mounted electric auger drills (fig. 8) are used, the auger steel having special detachable bits for drilling. Drills are powered by 1-1/2 horsepower, 220-volt, a.c. motors. Drilling speed is 28 inches a minute. Steel and bit wear are not excessive. Three lengths of steel serve to drill holes up to 11 feet in depth.

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[8] Hubbell, A. H., cited in footnote 7.

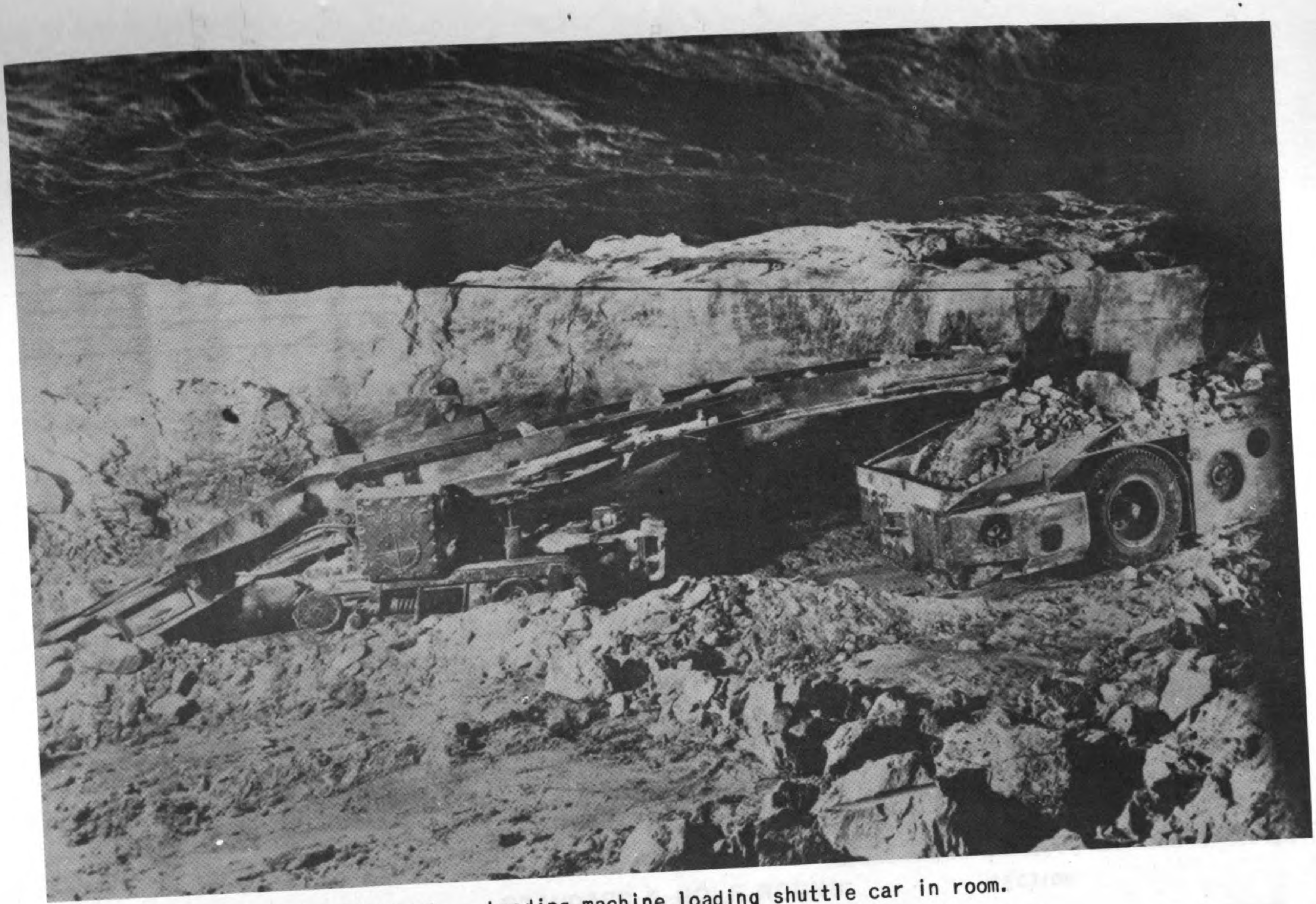

Figure 9. - Loading machine loading shuttle car in room.

(Courtesy of International Minerals & Chemical Corp.)

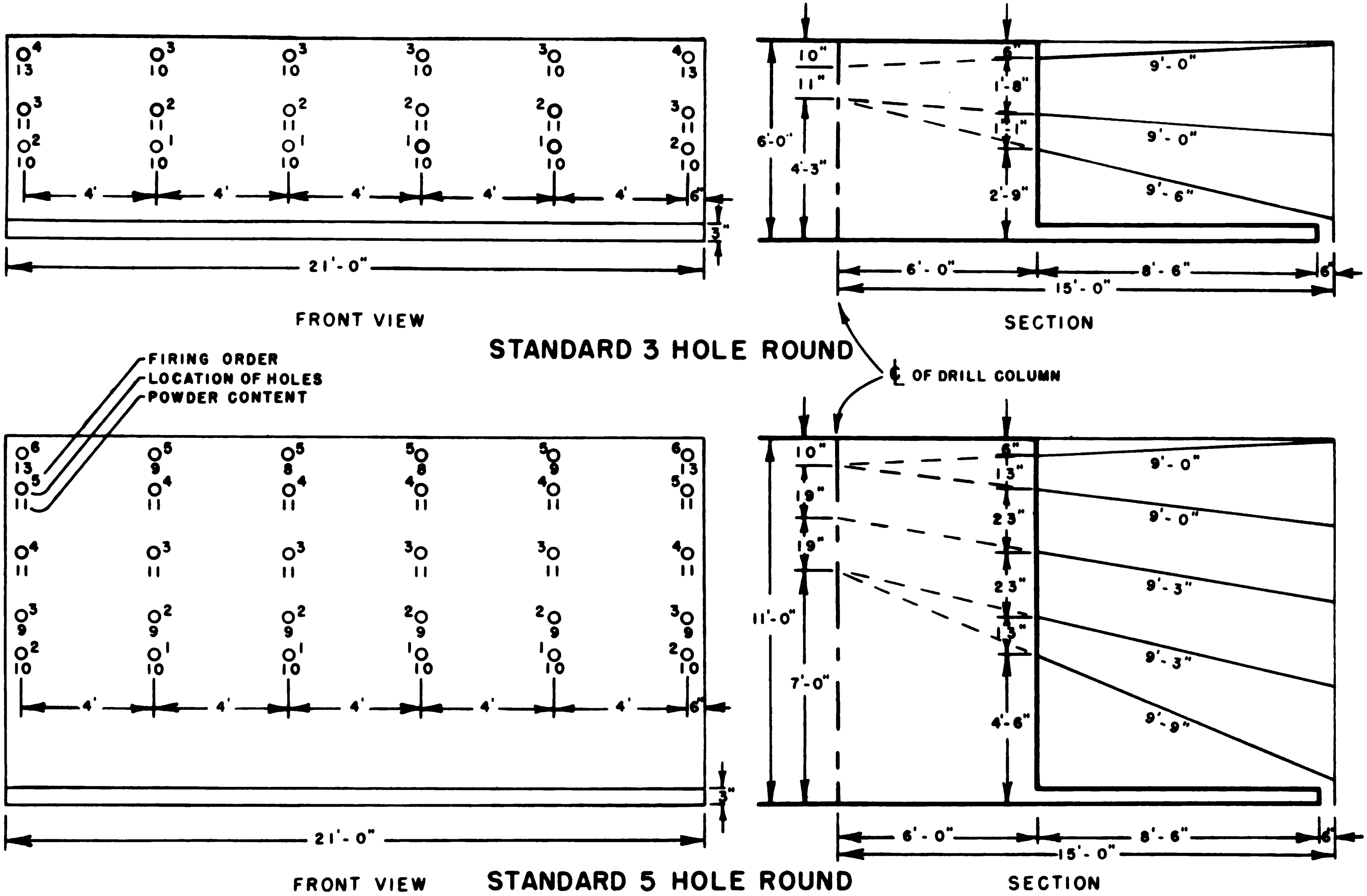

Figure 10. - Standard 3- and 5-hole entry rounds.

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At the start of operations on the 800-foot level in the langbeinite ore, wet-type compressed air-driven drills were used because of the hardness of the ore (langbeinite is about as hard as limestone). However, these drills soon were abandoned, because the salt dissolved in the water and also because of the attendant danger of short circuits in the electric equipment. Experimental work was done with special bits used in the electric post drill, and bits finally were perfected for auger steel that cut the hard langbeinite but at a substantial saving over the old air-drilling methods. The bit now used is 1-3/4 inches in diameter.

On the 900-foot level the electric post-mounted drill with auger steel has been used since the start of operations. Bit diameters are 1-3/4 and 1-5/8 inches. The drill round as used in entries is shown in figure 10. Usually 15 holes are drilled in an 8- by 16-foot entry in three rows, as shown. The sight line of the entry is marked on the face by the face boss by sighting from survey stations in the entry; then the position of each vertical row of holes also is marked on the face by actual measurement from the sight line. It has been found that just a matter of a few inches off on the location of the drill holes will result in a badly blasted entry, as the sylvite and salt formation (usually called sylvinite) is very spongy or rubbery. The langbeinite on the 800-foot level is brittle and breaks easily.

Blasting is done at the end of each shift. Separate magazines are provided on both levels for dynamite and primers. The latter are made up underground by the primerman and then are taken to the face to be blasted in specially constructed hand cases. On the 900-foot level powder is hauled to auxiliary magazines in specially insulated cars equipped with insulated couplings. Holes are fired electrically, the primers of each round being connected in series. The blasting circuit is taken from the regular 220-volt a.c. line, although a separate blasting line is available for use. Powder consumption is about 0.6 pound for each ton of langbeinite ore broken and 0.75 pound for each ton of sylvite ore. The top holes at each side of the face are loaded more heavily than the others, as they have a tendency to "collar."

MINING METHODS

Mining

As the room-and-pillar methods of mining potash had been used successfully by United States Potash Co. and by Potash Co. of America in the Carlsbad district, this method was used by International in mining their potash ores.

As described under Development Methods, double main entries were driven N. 56°04' E. through the sylvinite area on the 900-foot level, cross entries being turned off at right angles or normal to the main entries. These double cross entries (or panel entries) at first were turned off every 1,160 feet, but this was changed later to about 1,760 feet. Double main entries also were driven N. 56°04' E. from No. 2 shaft, as shown in figure 4. Mining panels were then laid out between these entries, 175-foot barrier pillars being left along each side of the double main entries and smaller chain pillars being left on each side of cross or panel entries. Where no main entries occurred, barrier pillars were left across the panel every 494 feet parallel to main entries. In each panel, rooms (fig. 11) were turned off at right angles to the cross entries, so that the rooms were parallel to main entries (N. 56°04' E.). These rooms were usually 36 feet wide and were driven about halfway to the next cross entry (see fig. 4). Breakthroughs, which also were 36 feet wide, were driven at 90° angles to the rooms or N. 33°56' W., leaving the pillars between rooms and breakthrough 34 by 42 feet. In the initial panels on the 900-foot level those pillars were 40 by 80 feet, but in later panels they were cut down to 34 by 42 feet.

On the 800-foot level, as the langbeinite ore body occurred very close to No. 1 shaft, main entries were driven just as on the 900-foot level; these double entries are above those on the 900. Main entries were driven 820 feet due north from the shaft, then turned N. 56°04' E., parallel to the 900-foot level entries. No work was done in the 450-foot shaft pillar except for entries (see fig. 4). At first, on the 800-foot level, rooms were driven N. 33°56' W. whereas breakthroughs were driven N. 56°04' E., exactly the reverse of those on the 900-foot level. Later workings were driven parallel to those on the 900.

The operational cycle in mining is about the same as in development work. The face is undercut, drilled, blasted, and the ore is loaded by trackless loaders into shuttle cars. Drilling and blasting have been described under the section on Development Methods. Undercutting, loading, and haulage are described below.

Undercutting

All room and breakthrough faces are undercut by shortwall undercutting machines (fig. 7), preferably before the face is drilled. Undercutters are equipped with 50-horsepower a.c. motors and have 9-foot cutter bars, which cut a kerf about 5-1/2 inches wide by 8-1/4 to 8-1/2 feet deep. Cutting speed is 6 to 7 inches a minute. Machines are transported from one working face to another on the 800-foot level on self-propelling, caterpillar-treaded trucks equipped with long trailing cables. These cables are plugged in at various points, and the truck carrying the undercutter is able to move from one section to another. A small electric fan is mounted on the truck for ventilating the face while the undercutter is working. A hand auger drill also is carried on the truck for drilling the anchor pin holes in the floor (cables from the undercutter are attached to pins placed in these holes). For long hauls on the 800 level the machines are loaded on trucks pulled by shuttle cars or a battery-operated mine tractor (fig. 12). On the 900-foot level these machines are moved from one face to another on the self-propelling trucks.

The undercutter makes a cut either just below the ore in the salt or along the lower edge of the ore. It is operated by an operator and a helper.

Loading and Haulage

All loading now is done by self-propelled, caterpillar-mounted loaders (fig. 9). Formerly, loading in rooms was done with a triple-drum electric

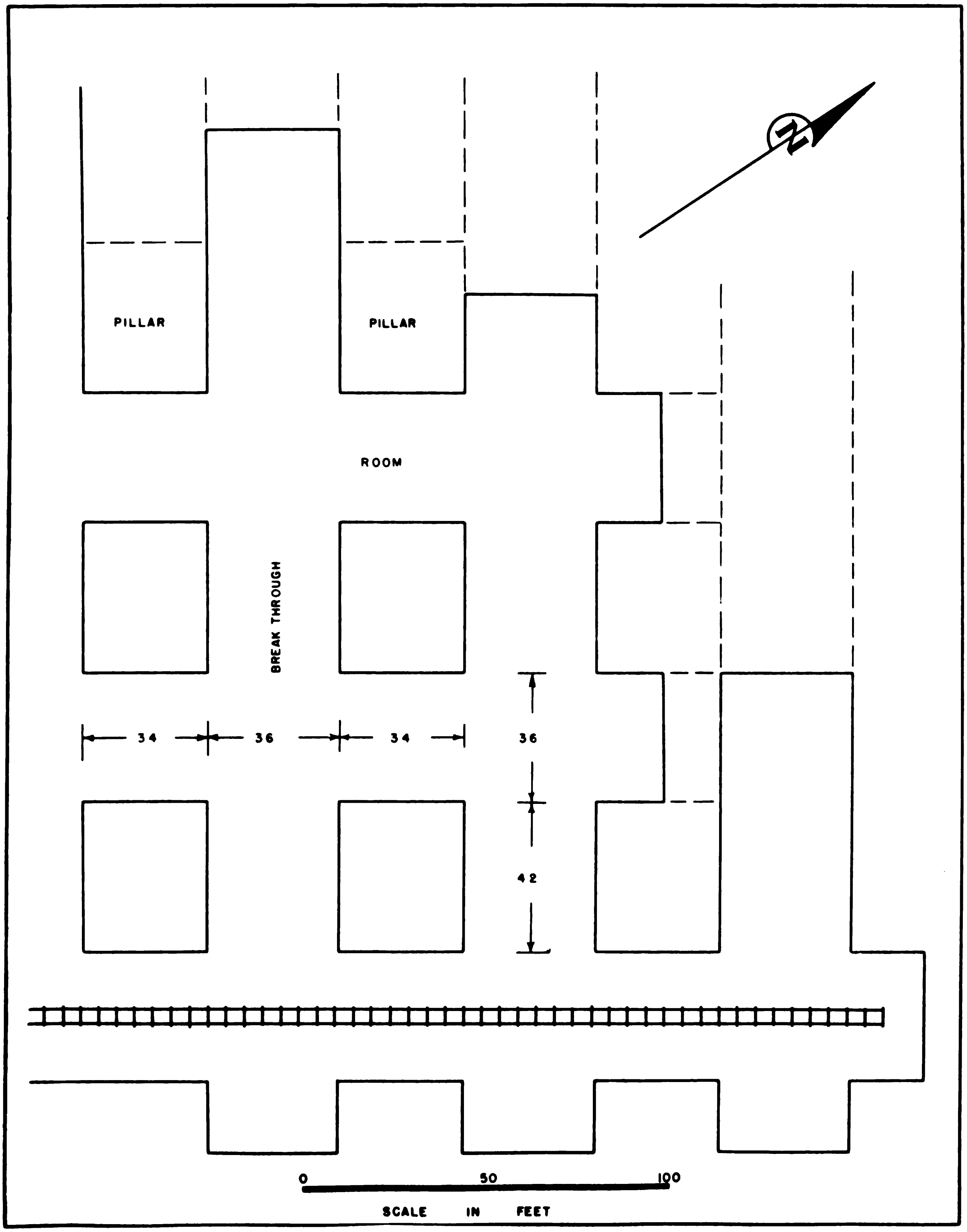

Figure 11. - Map of area on 900-foot level.

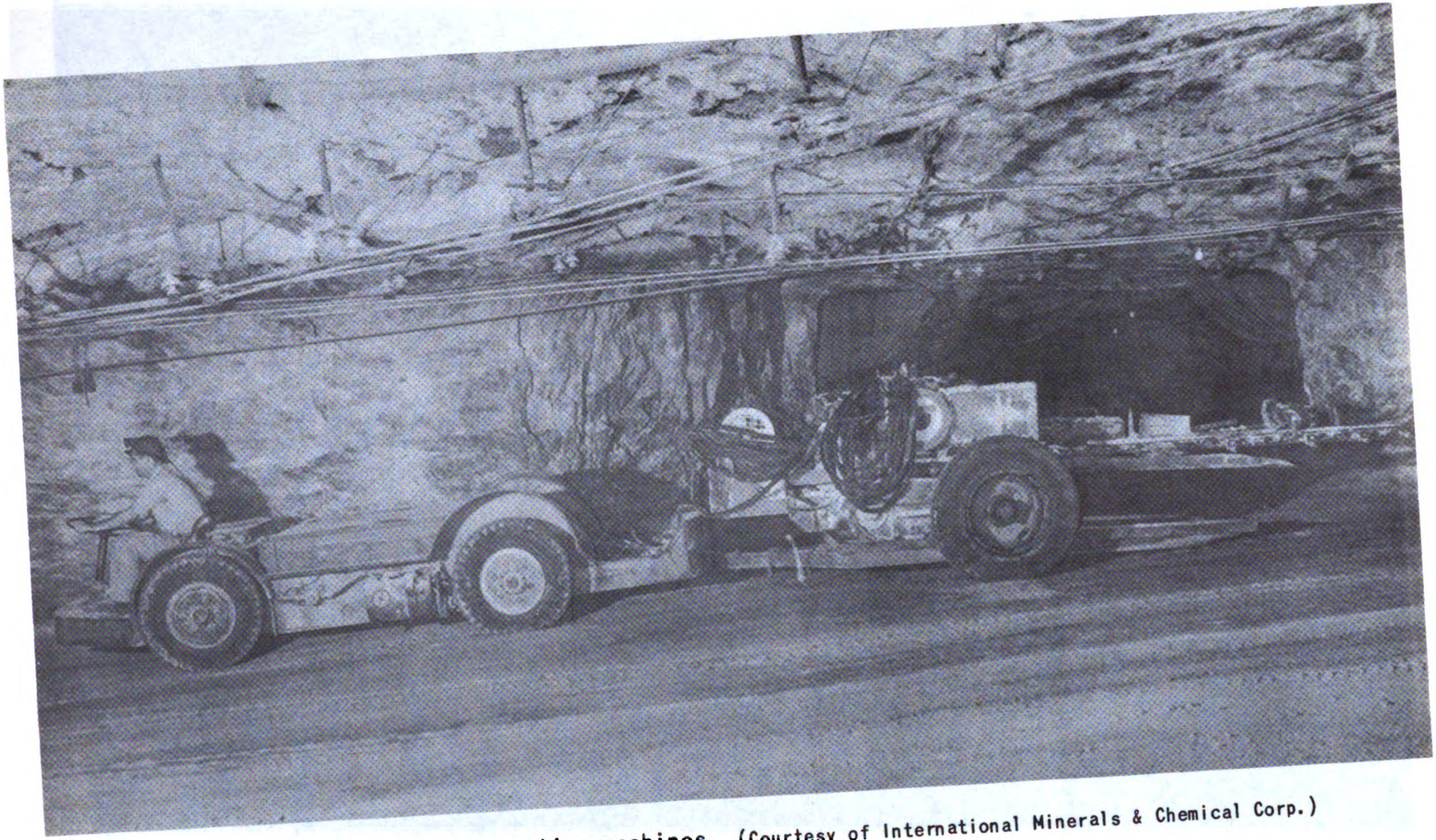

Figure 12. - Moving undercutting machines. (Courtesy of International Minerals & Chemical Corp.)

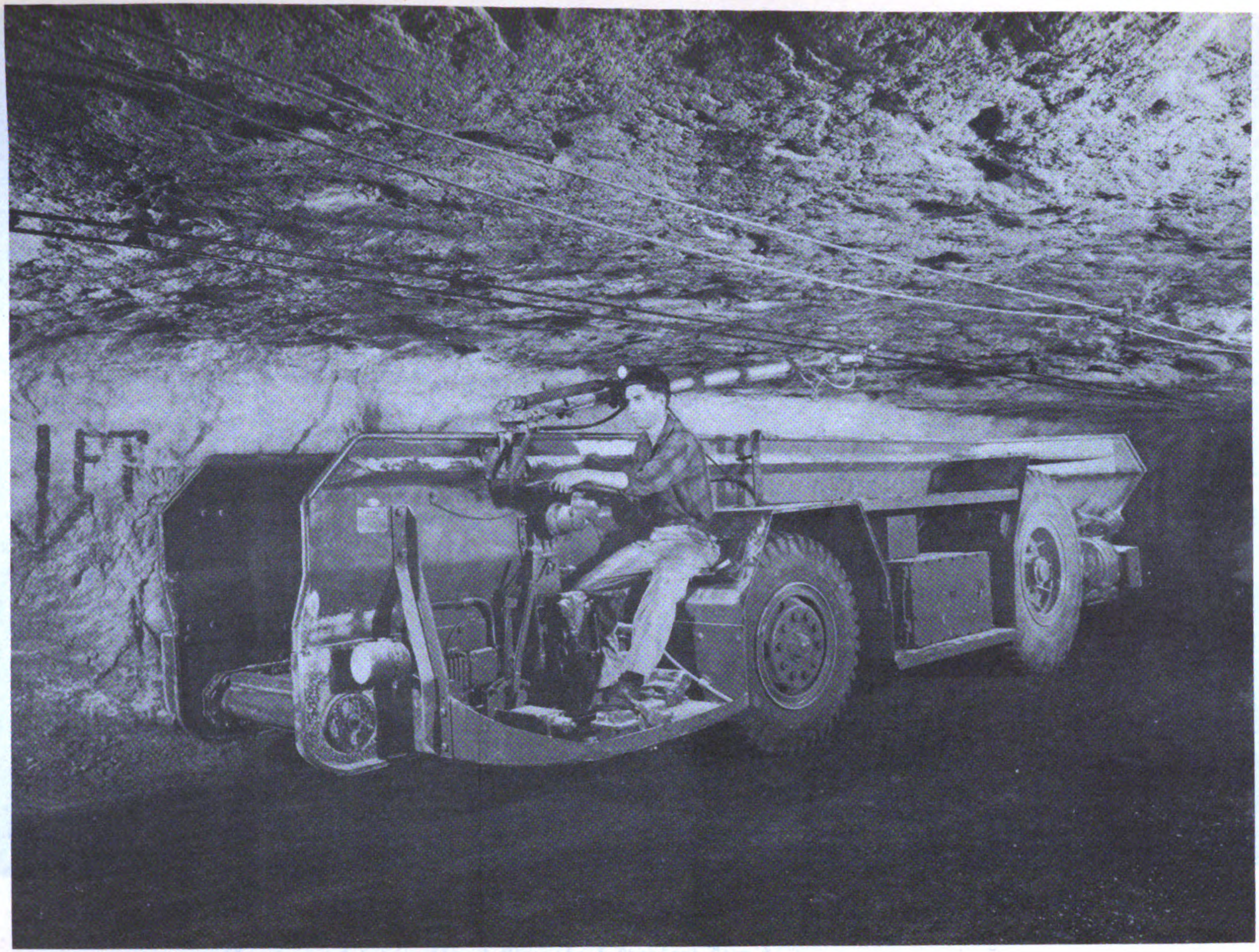

Figure 13. - Trolley-type shuttle car. (Courtesy of International Minerals & Chemical Corp.)

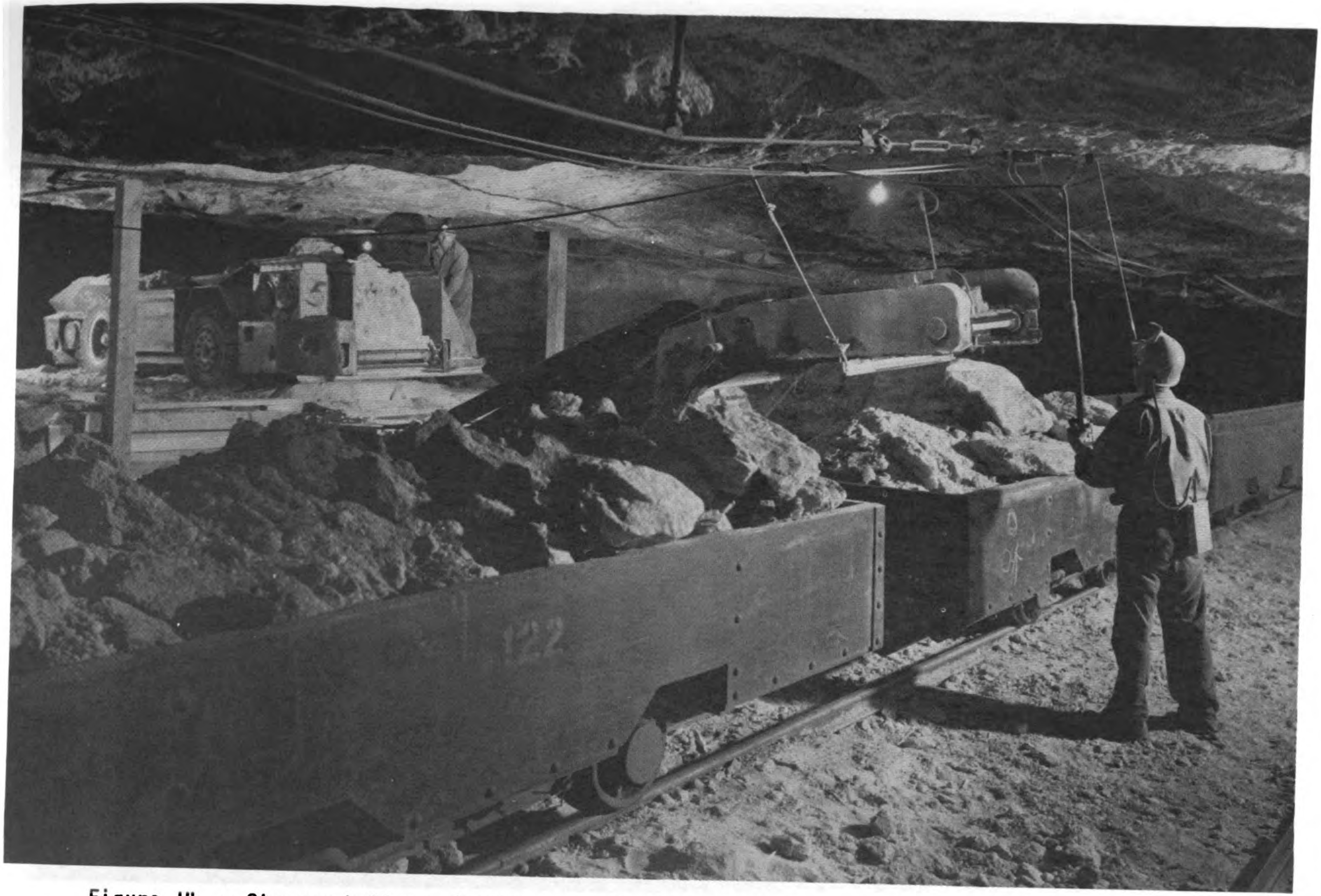

Figure 14. - Storage-battery shuttle-car unloading into conveyor, which is loading mine car.

(Courtesy of International Minerals & Chemical Corp.)

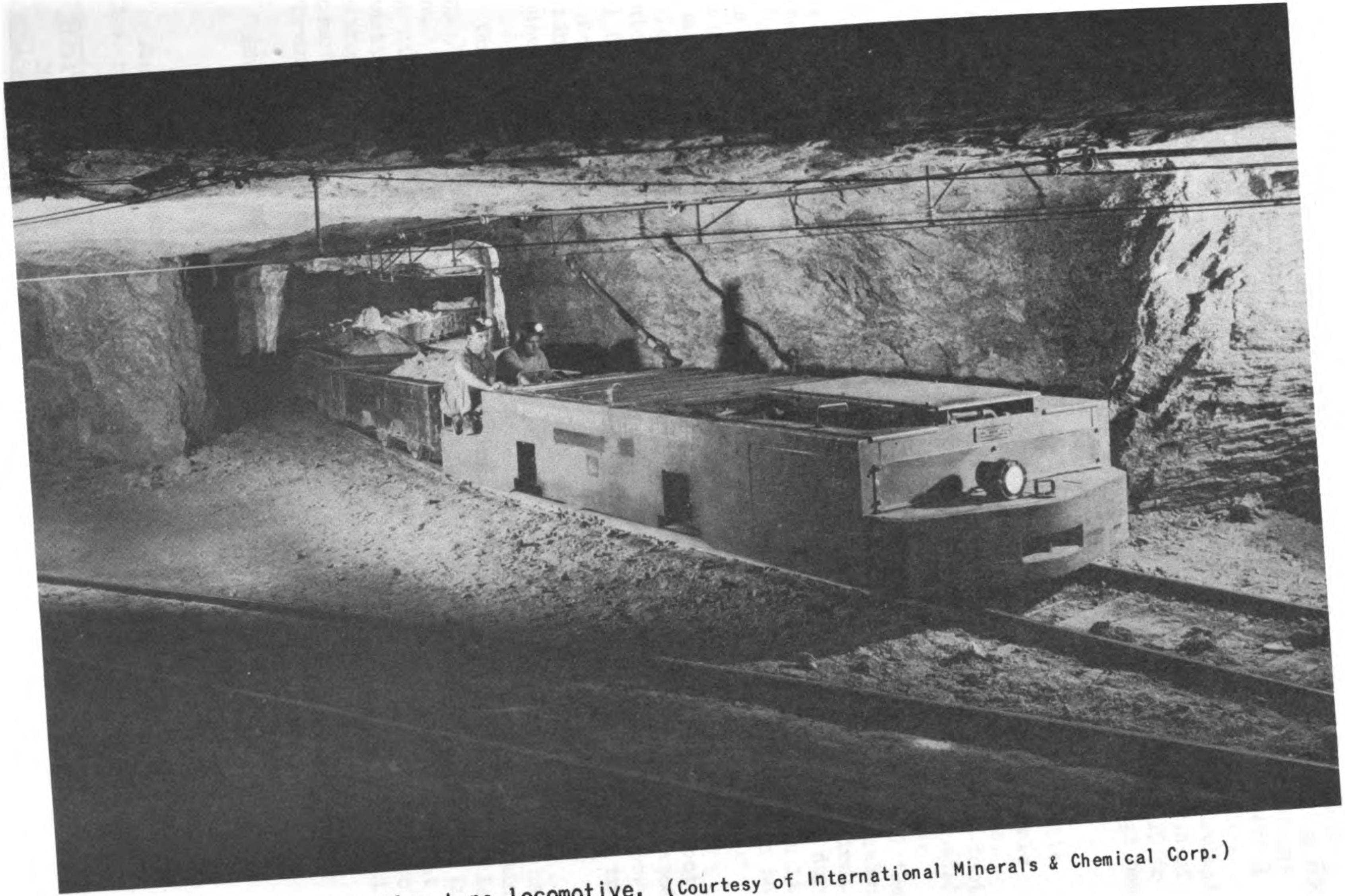

Figure 15. - Trolley-type locomotive. (Courtesy of International Minerals & Chemical Corp.)

hoist and scraper, but this method soon was abandoned for the caterpillar-mounted loader. These machines load directly into shuttle cars averaging 600 tons a shift. The machines are serviced at mid-shift, and preventive maintenance is practiced, with the result that direct repair labor and material costs are very low. A low truck with removable ramps is used on the 800-foot level to transport the loader for long distances. This truck is hauled by a shuttle car. One of these loaders can load 150 tons an hour of run-of-mine ore. It operates easily in piles 3 to 12 feet high and in rooms 15 to 36 feet wide. Two or three shuttle cars will serve one loader, although hauls should not be over 500 feet. A loader is operated by an operator.

On the 800-foot level, all haulage is done with rubber-tired shuttle cars (fig. 13).[9] These cars are of the trolley-cable reel type. Double trolley wires are placed in main and panel entries and in haulage rooms. The cars move up to the working faces from the entries by means of 600-foot trailing cables attached to the trolley lines. After these cars are loaded they travel back to the main haulage entry, where the ore is dumped into transfer raises. These raises go to the 900-foot level. On that level the ore is drawn out into mine cars and transported to No. 1 shaft. The roadway for the shuttle cars is maintained by sprinkling it with "bug dust" (fines made by the undercutting machine) and then wetting this dust. A hard, durable, smooth roadway results. Occasionally this roadway is dragged to smooth it. Hauls of 2,500 feet between the loader at the face and a transfer raise have been maintained with little drop in loading efficiency, except that four shuttle cars are required to serve the loader. A rubber-tired, battery-operated mine tractor (called a "jeep") (fig. 12) is used on the 800-foot level for hauling undercutting machine trucks, etc. A specially insulated rubber-tired truck is used for hauling dynamite from the shaft to the powder magazine. This truck also is pulled by the mine tractor. No track or trains are used on the 800-foot level.

On the 900-foot level, ore is loaded into storage-battery shuttle cars (fig. 14), which haul the ore to loading points and then dump it into mine cars. Track is laid in the first room north of barrier pillars. Shuttle cars discharge into mine cars either by the aid of ramps or by dumping into elevating conveyors, which then load into the cars. Cars are spotted at the loading points in the rooms and then hauled to main-line switches by trolley locomotives (fig. 15). Main-line locomotives are discussed in the section on Transportation.

Shuttle cars are operated by one man.

TRANSPORTATION

As has been mentioned, all haulage on the 800-foot level is by trolley-cable reel shuttle cars. Battery-operated tractors are used for moving

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[9] Harley, G. T., Three Years of Shuttle Cars at International's Potash Mine: Eng. and Min. Jour., vol. 145, No. 5, May 1944, pp. 62-65.
Harley G. T., Mechanization of Operations in Potash Mining: Min. Cong. Jour., vol. 32, No. 11, November 1946, pp. 24-28.

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equipment, hauling dynamite, etc. On the 900-foot level storage-battery shuttle cars haul and dump the ore into mine cars, track being laid along the rooms at 494-foot intervals.

On the 900-foot level, trolley or storage-battery locomotives are used for spotting and gathering cars in rooms and new entries. These loaded cars are taken to sidings in the main entries, where they are picked up by main-line trolley locomotives and taken to No. 1 shaft. The langbeinite ore from the 800-foot level is drawn from transfer raises on the 900 and hauled in mine cars to the shaft.

International uses 13-ton trolley locomotives for gathering and 20-ton ones for main-line haulage. Two 13-ton locomotives connected in tandem are planned for main-line service. The 20-ton locomotives then will be used for gathering service where severe grades exist. Spotting locomotives are 13-ton trolley or battery types.

All underground track gage is 42 inches. Sixty-pound rails are used in main and cross entries, whereas 40-pound rails are used in rooms. Untreated wooden ties are used in all track. The wooden ties are ballasted and tamped with undercutter "bug dust" or fine waste salt. Moisture from the air dampens this fill and makes a very good ballast as well as a preservative for the ties.

Mine cars are of the rectangular-body type holding 6.2 tons of run-of-mine ore. Swivel couplings are used. Cars are dumped by a rotary car dumper (fig. 16) at No. 1 shaft, being fed to this dumper by gravity. By using swivel couplings, cars do not have to be unhooked from the train while dumping.

From the rotary dumper the ore goes to a hopper and a pan feeder, which feeds the ore to a single-roll tooth crusher. Dumper and feeder can handle 250 tons an hour. Ore is reduced in the crusher to 5-inch, then goes to either of two bins - one for sylvite and the other for langbeinite ore. From these bins the ore is drawn into skip loaders, which automatically fill the 5-ton skips.

Hoisting in No. 1 shaft is done in balance in skips hung beneath cages. When one skip is loading below the 900-foot level, the other is dumping at the headframe on the surface. Hoisting is done by a double-drum hoist geared to an 800-horsepower d.c. motor operating from a 600-kilowatt, automatically governed, motor-generator flywheel set and using a 1-5/8-inch steel cable. Cages only are used in No. 2 shaft.

VENTILATION

During the initial development stage and before No. 2 shaft was completed, the manway compartment of No. 1 shaft was lagged off from the other two compartments. Fresh air was blown by a fan down this manway compartment to the 800- and 900-foot levels, thence to the working places through 1 entry of the double entry system, then returned to the shaft through the second entry, and

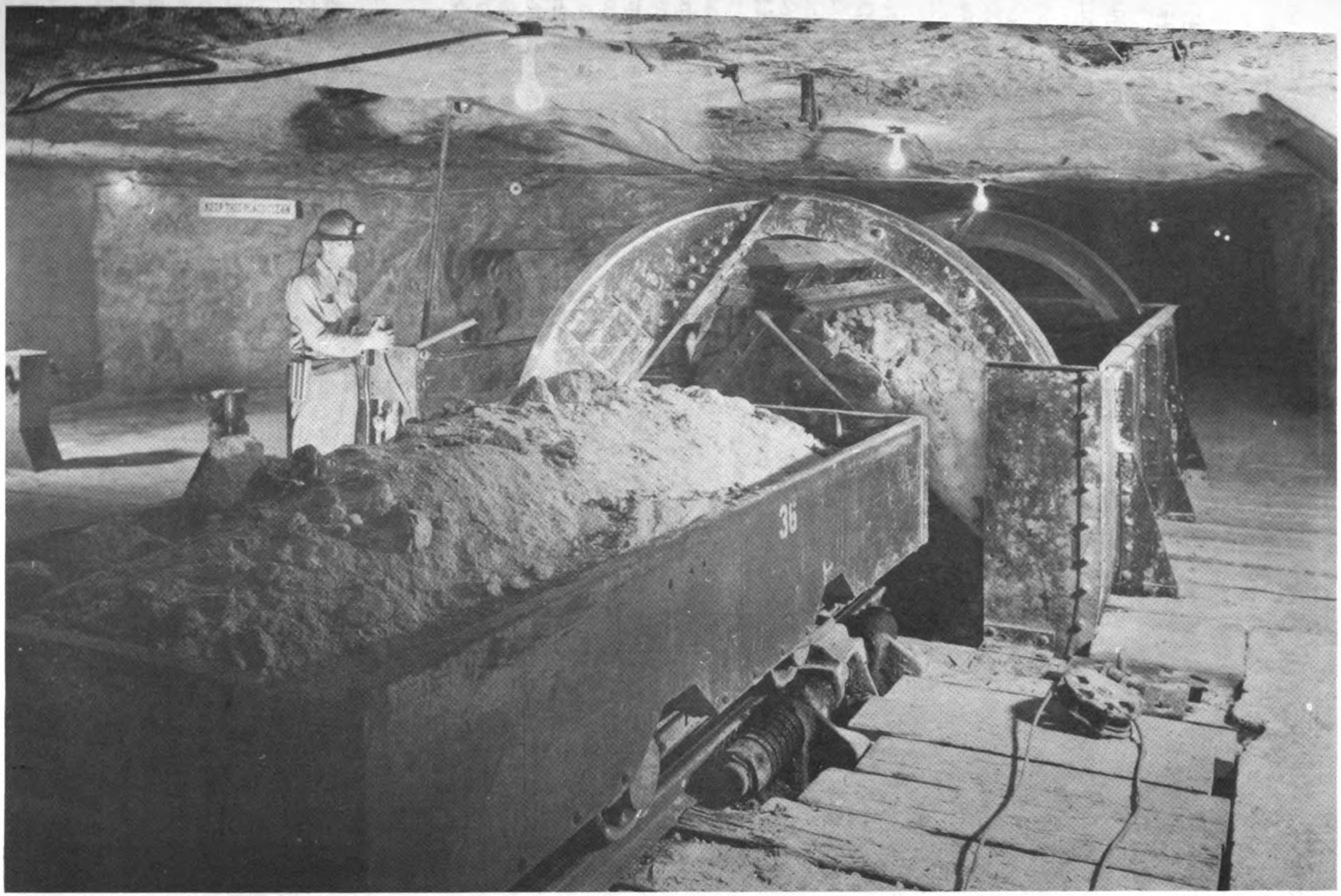

Figure 16. - Rotary dumper unloading cars at No. 1 shaft on 900-foot level.

(Courtesy of International Minerals & Chemical Corp.)

on to the surface through the hoisting compartments. Small auxiliary electric fans with canvas ventilation tubing were used to ventilate dead ends.

At present the mine is ventilated by fresh air that comes down No. 1 shaft and exhausts up No. 2 shaft. Forced ventilation is obtained from three 60-horsepower fans. One fan is on the 800-foot level directly north of No. 2 shaft. The other two fans are on the 900-foot level close to No. 2 shaft.

Some 130,000 cubic feet a minute of fresh air is drawn down No. 1 shaft. About 70,000 cubic feet a minute splits and goes to the 800-foot level and 60,000 cubic feet a minute goes to the 900-foot level at No. 1 shaft. The 900-foot level draws off about 30,000 cubic feet a minute from the 800-foot level at No. 3 raise.

The fresh air on the 800-foot level splits at No. 1 shaft, part of it going south and west and continuously ventilating panels 3 through 17. The other split goes north and east and ventilates the entries in the east part of the 800-foot level and panels 19 and 21.

The ventilation is very similar to that in coal mines where the room-and-pillar method of mining is used. Fresh air follows the main-line haulage and on through the haulageway of cross or panel entries, goes along the working faces, then through a panel regulator door to the return aircourse entry, and on to No. 2 shaft. Regulator doors at the end of each panel give panel ventilation control. Overcasts take this return air over haulageways. Canvas brattices or solid stoppings are used to seal off worked-out rooms and breakthroughs, so the fresh air goes only along the working faces. Wooden doors are used at the entrance of rooms and in breakthroughs that contain track (see fig. 3). Rooms that go through the panel barrier pillars are sealed off with solid stoppings. A wooden door is used at the most advanced room passing through the barrier pillar. Small portable electric fans with canvas ventilation tubing are used to ventilate dead-end entries, breakthroughs, and rooms.

DRAINAGE

No water was found while sinking No. 2 shaft. Water is pumped from No. 1 shaft as has been described.

The company normally obtains all water for plant use through a pipeline from Carlsbad to the mine site; water is also pumped to the mine from a deep well, or wells, near the Pecos River. Occasionally, water that is pumped from the No. 1 shaft pump station or from a deep well near the shaft is introduced into the circuit. Standby wells in the valley some distance from the surface buildings and shafts also may supply water in case of emergency.

SAFETY MEASURES

The promotion of plant safety is recognized as a highly important company policy and receives the cooperative support of all plant officials. As the success of any safety program depends largely on a harmonious and productive relationship of the entire plant personnel, the organization is headed by a superintendent of Industrial Relations for combining the safety regulations, working methods, and working agreements that have proved their value under operating conditions. A safety engineer has direct supervision of the safety work. Every effort is made to keep the program on a practical basis.

As a whole, the safety program does not differ radically from the commonly accepted form. Safety meetings are held for each underground crew at 6-week intervals. Motion pictures are shown frequently, and the various problems relative to safety are discussed at the same time. On the surface, the maintenance and construction crews and other crews that have hazardous occupations and occasional disabling injuries are called for periodical safety meetings.

Regular safety inspections are conducted monthly in conjunction with three Union Safety Committees of three men each, representing the mining department, the crushing, milling, and loading department, and the maintenance, construction, and power department. Other regular inspections are made quarterly with the New Mexico State Inspector of Mines, quarterly with the resident engineer of the insurance company, and semiannually with an engineer from the Safety Division of the Federal Bureau of Mines.

No effort is made to have a flashy or spectacular safety program. Reliance for results is placed on a conservative program that is continuously stressed by the supervisory staff. Safety is kept in front of each employee as often as is practicable and possible.

All accidents, regardless of severity, are investigated immediately, and statements are taken from the injured man and from witnesses to fix the responsibility. A complete analysis is made to determine the cause and to devise remedies that will avoid a recurrence.

Variant and frequent safety inspections are made by the Safety Engineer as follows:

1. To visit with the men on the job and to see that safety is not merely taught but is practiced.

2. To discover hazards and faulty habits and correct them before accidents occur.

3. To make a point of checking the use and care of tools, equipment, and all other safety devices.

4. To promote and see that good "housekeeping" is observed.

5. To see that safety rules and regulations are complied with and to observe the need for additional rules, signs, and notices.

6. To locate, inspect, and keep serviced all plant fire-fighting equipment.

7. To see that all parts of the mine are adequately ventilated and make periodic ventilation tests and surveys.

8. To distribute first-aid supplies, safety posters, and other safety messages.

9. To discover any occupational health hazard, unsanitary condition, or fire hazard, and to propose improvement.

Accident reports are required for each accident, regardless of its severity, and employees are urged to take even trivial injuries to the first-aid room. All accidents are reported immediately to the insurance carrier so that employees may be protected if a minor injury develops into something serious and becomes compensable. Accident statistics are maintained in the form of charts, graphs, and other visual aids to measure results and to plan the safety program.

Accident frequencies and severities during plant operations are as follows:

Year	Frequency	Severity
1941	54.35	12.06
1942	52.40	9.79
1943	18.15	1.56
1944	18.60	4.22
1945	17.11	3.08
1946	20.20	2.25

WAGE SCALE

The following wage scale was in effect at the International Minerals and Chemical Corp.'s potash mine as of August 21, 1947:

Mine Department:	Hourly rate
Relief repair foreman	$1.81
Leadman	1.71
Powderman	1.64
Miner	1.64
Shaftman	1.64
Loading-machine operator	1.64
Undercutter operator	1.64
Motorman	1.64
Shuttle-car operator	1.64
Trackman	1.64
Maintenance man, 1st class	1.64
Welder	1.64
Lampman	1.64
Cager	1.58
Driller	1.56
Ventilation man	1.54
Grizzlyman (while working)	1.52
Pipeman	1.51

Mine Department:	Hourly rate
Undercutter helper	$1.50
Primerman (not handicapped)	1.50
Bar-down man	1.48
Maintenance man, 2d class	1.48
Trip rider	1.41
Cager helper	1.41
Track helper	1.41
Ventilation helper	1.40
Top lander	1.40
Maintenance helper	1.36
Primerman (handicapped)	1.36
Mucker	1.33
Power department:	
Mechanic	1.64
Operator	1.64
Centrifuge man	1.48
Fireman (steam)	1.48
Electrical department:	
Leadman	1.74
Journeyman electrician	1.64
4th year apprentice electrician	1.56
3d year apprentice electrician	1.45
2d year apprentice electrician	1.39
1st year apprentice electrician	1.36
Mechanical department:	
Oiler and pumper boss	1.70
Journeyman machinist	1.64
Journeyman mechanic	1.64
Journeyman automobile mechanic	1.64
Journeyman blacksmith	1.64
Advanced apprentice	1.54
2d class craftsman	1.48
Journeyman's helper	1.36
No. 1 shaft hoistman	1.73
No. 2 shaft hoistman	1.65
Lampman	1.64
Dragline operator	1.64
Caterpillar operator	1.54
Oiler and pumper	1.47
Oiler (storage and loading)	1.36
Automobile service man	1.36
Oiler laborer	1.20
Sampling and laboratory department:	
Surface sampler, 1st class	1.31
Sampler laborer (present employees)	1.16
Sampler laborer (new employees)	1.14

Miscellaneous department:	Hourly rate
Truck driver (while working)	$1.36
Common labor department:	
Laborer (present employees)	1.16
Laborer (new employees)	1.14
Laborer, while operating cement mixer	1.33
Laborer, while operating jackhammer	1.33

1. In addition to above base rates, all employees who work on rotating shifts receive additional shift premium of 4 cents per hour for afternoon shift and 8 cents per hour for graveyard or night shift.

2. All employees also participate in a production bonus. For the calendar year 1946 this bonus averaged 21.94 percent.

ORGANIZATION

The mine organization of the Potash Division of the International Minerals & Chemical Corp. at their plant in Eddy County, N. Mex., consists of a general manager, who directs all company operations in the district; a mine superintendent, who directs all mine operations; a chief engineer, who supervises all engineering work; a superintendent of industrial relations, who supervises all work in connection with employee relations; a safety engineer, who works under the supervision of the superintendent of industrial relations and who directs safety and ventilation work in the mine; and two mine foremen, several shift bosses, and several face bosses in the mine. Most mine labor is under the direct supervision of shift and face bosses.

Owing to the isolated position of the plant, a large machine shop is maintained that can handle nearly any major mechanical or electrical repair work. The concentrator, a large warehouse, a powerhouse, and an office also are at the plant. A complete laboratory is near the main shaft, where routine chemical and analytical work as well as research work is done.

A lunch room maintained by the company is at the plant. Many employees eat a hot lunch there. A few houses are provided at the mine for essential workers, but most employees live in Carlsbad and ride to and from work in their own cars or in busses (a regular bus line runs from Carlsbad to the mine).

APPENDIX

Mine Operating Data

On the 900-foot level the rooms and breakthroughs are excavated for a width of 36 feet. The excavated height, which is a variable, averages 9.5 feet at the present time (last quarter 1947). Rooms and breakthroughs are undercut for about 8.25 feet. Thus, each round represents 2,822 cubic feet or 185 tons of ore. The actual time required to undercut a 36-foot face averages 60 minutes, whereas the average feet cut per undercutter machine shift is 132. Time spent per shift in actual cutting amounts to 3 hours 11 minutes, leaving 3 hours 53 minutes for travel time, servicing machines, moving equipment, etc.

Drilling operations are conducted by a crew of two or three drillers drilling a 36-foot face. Forty or 50 holes are required to drill such a face, 4 or 5 holes to the vertical row, depending upon the height of the face. Rows are uniformly spaced four feet apart (fig. 17). Forty-six holes are drilled per man-shift, requiring 4 hours 59 minutes. Two drillers can drill a 40-hole face in 1 hour 48 minutes.

Mucking is done by one man operating a loading machine that discharges the ore into a battery-powered shuttle car on the 900-foot level or into a trolley-cable-reel-type shuttle car on the 800. Two, three, or four shuttle cars are assigned to each loading machine. At times, depending on the condition of the muck pile, a loader can load at the rate of 7 tons in 50 seconds. In general, depending on the number of shuttle cars, length of haul, and height of back, a 36-foot face can be mucked out in 55 to 75 minutes. Average loading time for loaders is 4 hours 29 minutes a shift, leaving 2 hours 34 minutes for travel time, servicing the machine, moving, etc. For the fourth quarter of 1947, 617 tons of ore and waste were loaded per loading-machine shift on the 900-foot level.

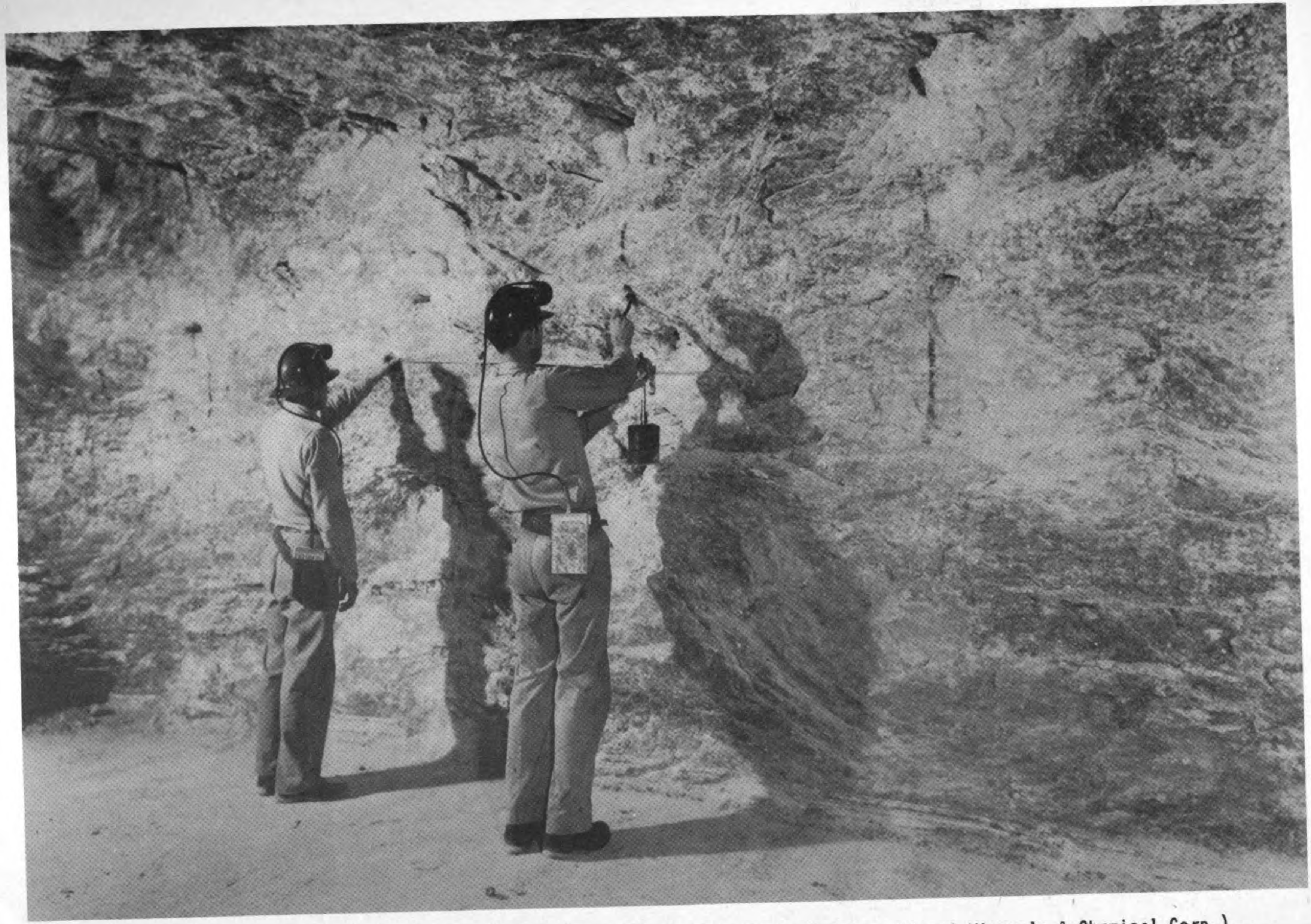

Figure 17. - Spotting drill holes on room face. (Courtesy of International Minerals & Chemical Corp.)

BIBLIOGRAPHY

1. Wroth, Jas. S. Special Features of Core Drilling in the Salt Beds of Western Texas and New Mexico. Bureau of Mines Inf. Circ. 6156, 1929, 13 pp.

2. Hayes, E. P. Supplementary Notes on Core Drilling in the Salt Beds of Western Texas and New Mexico; Tests 13 to 24. Bureau of Mines Inf. Circ. 6679, 1933, 11 pp.

3. Wroth, Jas. S. Commercial Possibilities of the Texas-New Mexico Potash Deposits. Bureau of Mines Bull. 316, 1930, 144 pp.

4. Schaller, W. T., and Henderson, E. P. Mineralogy of Drill Cores from the Potash Fields of New Mexico and Texas. Geol. Survey Bull. 833, 1932, 124 pp.

5. Turrentine, J. W. Potash in North America. Reinhold Publishing Corp., New York, 1943, 186 pp.

6. Mansfield, G. R., and Lang, W. B. Government Potash Exploration in Texas and New Mexico. Trans. Am. Inst. Min. and Met. Eng., 1929, pp. 241-255.

7. Smith, H. I. Potash in the Permian Salt Basin. Ind. Eng. Chem., vol. 30, No. 8, August 1938, pp. 854-860.

8. Hubbell, A. H. The Union Potash & Chemical Company's Enterprise at Carlsbad. Eng. and Min. Jour., vol. 142, No. 4, April 1941, pp. 43-71.

9. Harley, G. T. Three Years of Shuttle Cars at International's Potash Mine. Eng. and Min. Jour., vol. 145, No. 5, May 1944, pp. 62-65.

10. Harley, G. T., and Weaver, G. C. Prospecting for Potash in the Permian Basin Area Near Carlsbad, N. Mex. Am. Inst. Min. and Met. Eng. Tech. Pub. No. 2056, Chicago Meeting, February 1946, 6 pp.

11. Harley, G. T. Mechanization of Operations in Potash Mining. Min. Cong. Jour., vol. 32, No. 11, November 1946, pp. 24-28.